Nalco CGMax^{TM}: A tool for alumina yield improvement and product quality control

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Abstract

Alumina refinery operators have to control alumina product quality within prescribed specifications demanded by smelter operators, as well as for environmental and operational reasons. At the same time operators want the highest possible liquor productivity (alumina yield) from their precipitation circuits. Experience shows that precipitation conditions that favour good product quality are often times opposed to those that favour high liquor productivity. Nalco has developed a new generation of crystal growth modifiers (CGMax) that have high trihydrate coarsening potency and allow for both high yields to be pursued in the precipitation circuit while maintaining product granulometry within specification.

Keywords: Bayer; precipitation; crystal growth modifier; alumina quality; Nalco CGMax

1. Introduction

The Renukoot alumina refinery located approximately 160 km from Varanasi in Uttar Pradesh in India is also part of Hindalco's integrated aluminium production facility at the site. First commissioned in 1962 the facility includes bauxite mining, the Renukoot alumina plant and an aluminium smelter as well as downstream rolling and extrusion operations. The alumina refinery processes local bauxite, using conventional Bayer process technology and has a capacity of 700 000 tonnes per annum, making it the largest of Hindalco's alumina plants in India.

As with all alumina producers, optimization of operations throughout the circuit is a constant aim for the Renukoot plant. In 2014 a particular focus was achieving better performance from the precipitation area of the plant – specifically, improved control of product sizing to the appropriate specification together with enhanced precipitation yield. In discussions with Nalco staff, the potential application of a recently developed range of new crystal growth modifiers, the CGMax technology, was seen as a possible means to achieve the required goals.

While the refinery had previously used crystal modifiers from a range of suppliers, the enhanced performance and specific properties that the CGMax products offered were seen to potentially achieve a far better outcome. As a result, a process of assessment to identify the most appropriate product was instigated and plant trials were conducted over a number of months. The results and outcomes of this program are the subject of this paper.

2. Use of crystal growth modifiers

Crystal growth modifiers or CGMs were originally developed and commercialized by Nalco in the 1980's [1]. The original formulations were mainly targeted at coarsening the particle size distribution of precipitated trihydrate alumina and enhanced particle size control has continued to be the primary reason for use of CGM more broadly across the industry. More recently however, a range of additional properties and potential benefits of CGM use have been developed and recognized. These include the potential impact on oxalate stability and morphology [2], as well as the impact of reducing occluded soda [3] and enhanced particle toughness [4]. In addition, a great deal of work has been focused on obtaining a comprehensive understanding of the mechanism of the action of crystal growth modifiers [5, 6] as well as their impact under a variety of dosing regimens and process conditions [7, 8, 9]. A number of case studies outlining plant experience with CGM use have also been published [4, 10].

Building on the first generation of CGM products, Nalco has more recently developed a second generation of CGMs which, along with the original products, define the CGMax range [11]. This broader range of products means that the optimum product can be chosen for individual refineries to deliver the most effective coarsening impact, along with additional properties which may be desirable.

In general terms all the CGMax products have the same general mechanism to enhance trihydrate particle sizing. Despite their name, there is little evidence that crystal growth modifiers actually have any impact on growth of trihydrate particles. The major impacts on precipitation are improved agglomeration as well as inhibition of secondary nuclei formation [6].

It should be noted that all CGMax products can only enhance these existing mechanisms when they occur. CGMax products do not act as “glue” to promote particle aggregation in the absence of cementation via crystallization of trihydrate from solution. The liquor conditions must be sufficiently supersaturated and appropriate seed of suitable size and quantity must be present for any CGM to function. As a result, assessment of performance under lab conditions typically involves short precipitation tests using highly supersaturated (typically LTP) liquor seeded with fine seed solids. Standard test conditions have been used throughout this work [11].

The new generation of CGMax products are typically much more effective in achieving a coarser particle size distribution from precipitated trihydrate. Figure 1 shows the dose response of a conventional (first generation) CGM product versus one of the new CGMax (second generation) products in a standard laboratory test. The data is plotted as a change in the % +45 μm against the dose of modifier measured as a function of the available seed surface (mg of product per m^2 of seed surface).

As surface active agents, the dose required of any crystal modifier will be dependent on the surface area of seed material available. Typically in plant operations seed is measured on a mass basis, but for a more detailed comparison, as presented here, equivalence in terms of seed surface area is more appropriate.

Regardless of the measure, it is clear from this data that, while both products are effective in reducing fines (that is, increasing the amount of % +45μm material resulting from the crystallization process), clearly the new CGMax material is significantly more effective in coarsening the precipitated trihydrate.

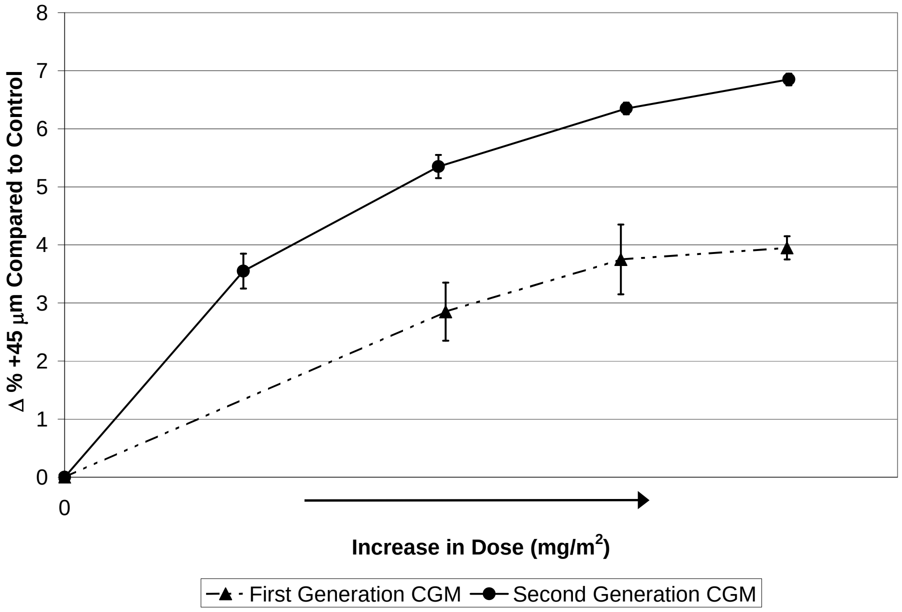

Figure 1. Dose response comparison (relative % +45 μm) of a conventional CGM and a second generation, CGMax product.

The property of reduced fine material in the precipitated product that CGMax products deliver can be used by plant operators in one of two ways:

1. CGMax can be used as a remedial treatment to reduce fines and bring the precipitated product back to an acceptable size distribution which is in line with product specifications. As such it can be used to "fix" a problem where the trihydrate produced from the plant is too fine, then the CGMax can be turned off when the plant operation returns within acceptable limits.
2. Alternatively CGMax can be used as an independent control agent for sizing, which allows plant operators to manipulate process parameters such as temperature and seed charge to maximize yield. In the absence of CGMax, such manipulation of these process controls would typically result in unacceptably fine product trihydrate. However, with appropriate doses of CGMax, product sizing can be maintained within the require specifications. In this way, CGMax is an enabler for plants to increase yield.

A simple demonstration of this latter approach is shown in Figures 2 and 3 where laboratory results in terms of yield and size distribution is plotted for a series of tests under a range of CGMax dose conditions using different seed charge (Figure 2) or temperature (figure 3).

In each case the CGMax materials result in a coarser product. This outcome from CGMax use can be coupled with process conditions to deliver increased yield, without the undesirable result of finer product. The impact of a range of CGMax products are shown in Figures 2 and 3. Clearly, the more effective the CGMax product is in coarsening the trihydrate, then the greater the potential for enhanced yield.

Typically, in plant operations CGMax can be used as either a remedial treatment in an on/off fashion to help reduce fines, or else as an enabler of increased yield, where it is typically used continuously while the other key process parameters are manipulated to maximize the amount of trihydrate produced.

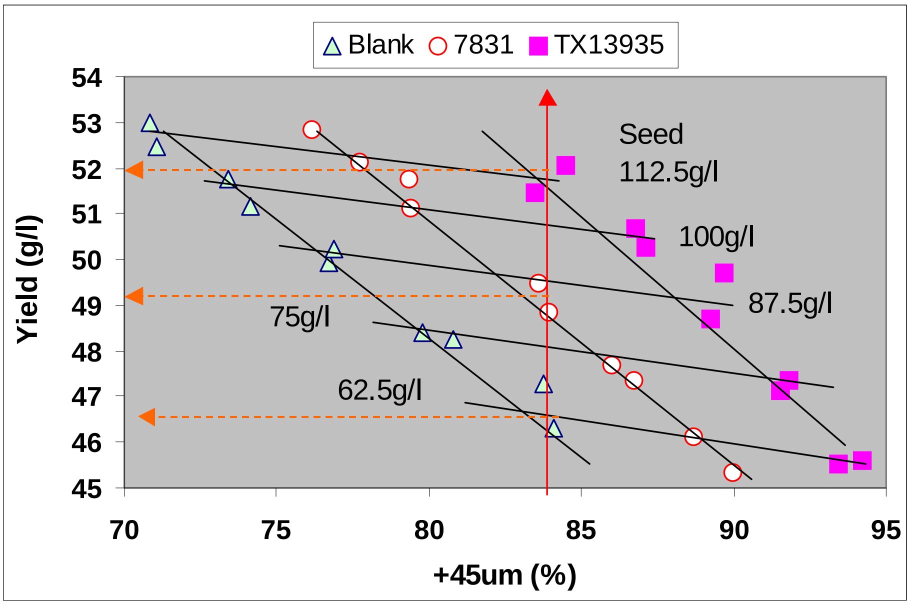

Figure 2. Effect of seed charge on particle size (+45 µm fraction, %) and yield (g/L), after t= 4 hours, using plant liquor and temperature = 72°C. CGM = 1.3 mg/m^2. Start Liquor: A = 180 g Al_2O_3/L, C = 249 g Na_2CO_3/L and S = 293 g Na_2CO_3/L. From Ref [9].

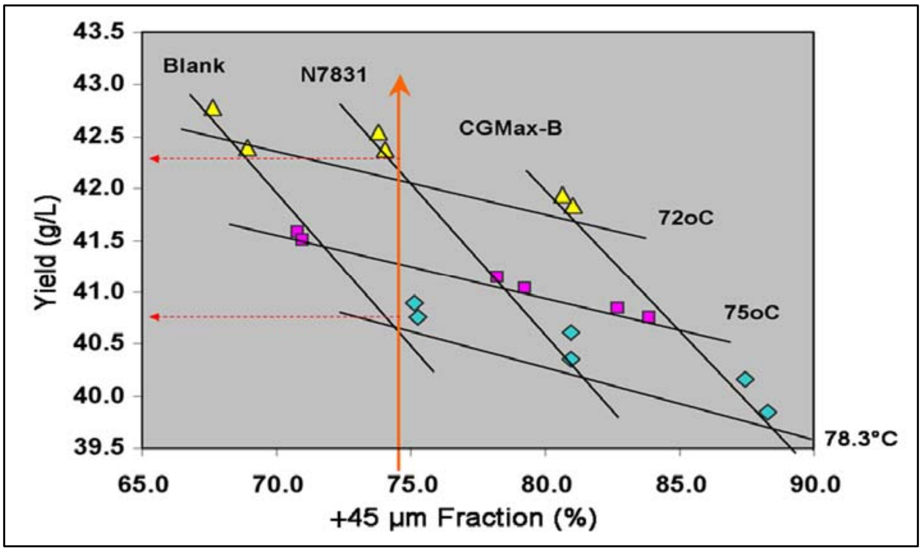

Figure 3. Effect of temperature on particle size (+45 µm fraction, %) and yield (g/L), after t = 4 hours, using plant liquor and temperature = 72°C. CGM = 1.3 mg/m^2. Start Liquor: A = 180 g Al_2O_3/L, C = 249 g Na_2CO_3/L and S = 293 g Na_2CO_3/L. From Rref [9].

In considering the use of CGMax, the Hindalco Renukoot operations staff identified that both these modes of operation could be used to enhance plant efficiency. Based on a consideration of particular requirements of the Renukoot plant, and following extensive internal comparison of both the new CGMax products and conventional crystal growth modifiers, one of the CGMax products, DVS4M019, was selected as the most appropriate product for the Renukoot plant and recommended for trial.

3. Plant application of CGMax at Hindalco Renukoot

Once selected as the product of choice, it was determined that the efficacy and benefits that could be delivered by using DVS4M019 would be assessed in a trial program of two phases. The first phase was aimed at simply assessing the coarsening impact of the product under plant conditions. This was achieved by measuring the amount of product material less -325mesh while dosing the product over an extended (~ 3 month) period.

The second phase was aimed at extracting yield benefits in the plant and optimizing production under CGMax dosed conditions by manipulating plant operations.

Phase 1 of the trial commenced in September 2014 with dosing of CGMax (DVS4M019). Note that prior to switching to the CGMax material, an alternative coarsening agent from another supplier was being added to the LTP liquor. The data for trihydrate product % -325 mesh in the period directly prior to the switch to CGMax is shown in Figure 4.

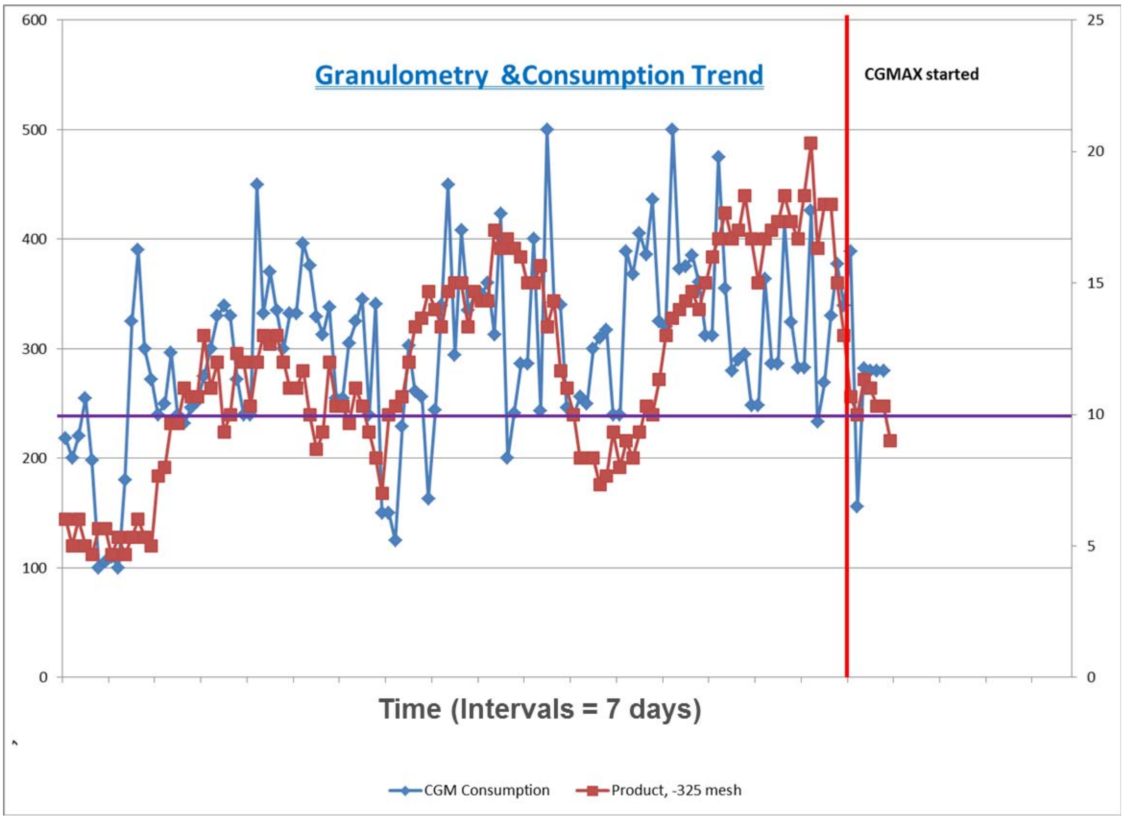

Figure 4. Typical plant results for trihydrate product -325 mesh over an extended period immediately prior to, and shortly after starting use of CGMax.

Clearly the introduction of CGMax had an immediate and dramatic coarsening impact on the product trihydrate. The goal of the plant is for product trihydrate to lie within a band of % -325 mesh between 8 - 13 %. Unfortunately prior to the use of CGMax, this goal was rarely met.

Use of CGMax continued and figure 5 shows data over the subsequent period. It should be noted that during the period from mid-October to early November the plant was operating at very low A/C. As a result, the precipitation circuit was operating with feed liquor which was very limited in supersaturation. Under these circumstances the CGMax would not be expected to appropriately function and such an outcome was indeed observed during this period with the product material recording much higher % -325 mesh. When a higher A/C was restored to the feed liquor in early November, the impact of the CGMax on size distribution of the product was again observed.

Apart from this aberration due to the change in liquor concentration, the product sizing across the whole period from late September to early December essentially remained within the target band of 8 - 13 %. Once the CGMax was no longer added, when dosage stopped in late December, the effect on product sizing was again readily observed.

In addition, it was noted that foam control on the tanks when the CGMax was in use was very good and no detrimental downstream process issues attributable to CGMax addition were observed. Overall the use of CGMax under plant conditions was shown to be extremely effective in improving product trihydrate sizing and enhancing the overall size control within the operation.

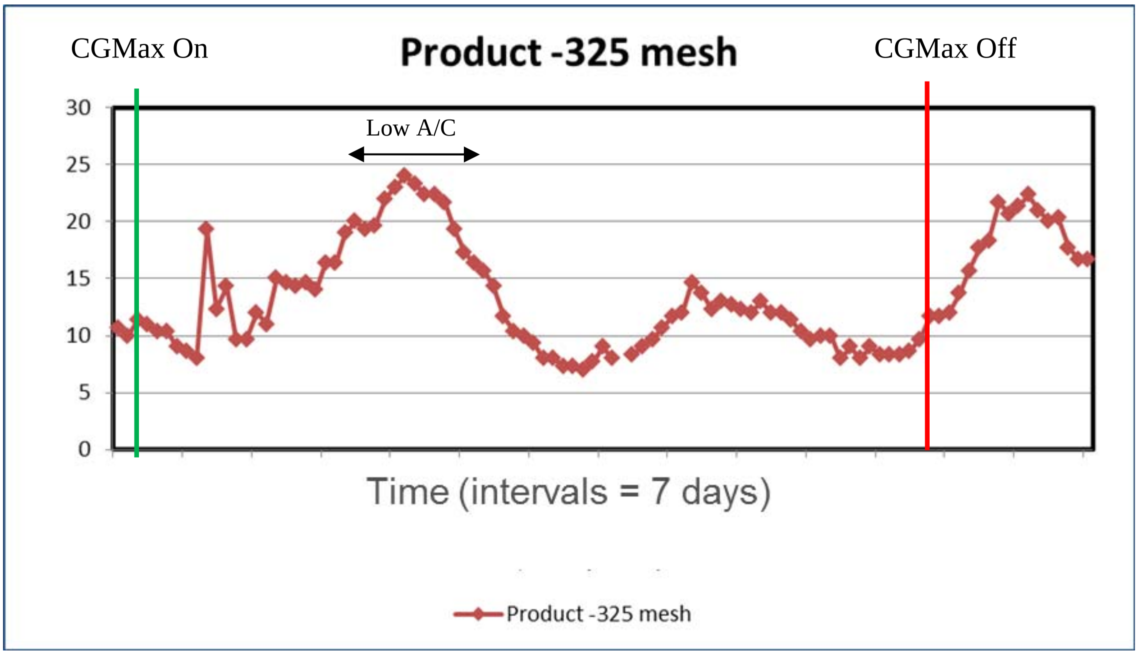

Figure 5. Plant trihydrate % -325 mesh over the period of the phase 1 trial.

Phase 2 of the trial work involved manipulating the plant operating conditions to deliver enhanced yield, while using CGMax to maintain particle size control. The overall strategy is summarized in Table 1.

Table 1. Key variables assessed and monitored in phase 2 of the plant trial.

Control Parameter	Change in Parameter	Potential Impact on Yield	Impact on Product particle sizing	Particle Size with CGMax
Temperature	Decrease	Increase	Finer	In spec (coarser)
Initial A/C	Increase	Increase	Finer	In spec (coarser)
Seed Charge	Increase	Increase	Finer	In spec (coarser)

While some attempt was made to manipulate the control parameters in a systematic fashion, the realities of plant operation meant that this was not always possible (or even desirable). Nonetheless, the appropriate information was able to be extracted simply by assessing the existing plant data as routinely monitored. The results are shown in Figures 6 - 9 which show average monthly data for April, May and June 2015. During this period CGMax was used on a constant basis.

In the month of June, the process was subjected to significantly higher seed charge than in previous months. In the absence of CGMax addition, this would typically have resulted in finer product being reported with a substantial increase in % -325 mesh. However, sizing results during this period (Figure 8) were generally maintained within the required specification. At the same time, the increase in yield that might be expected from increasing seed charge (Figure 9) was delivered.

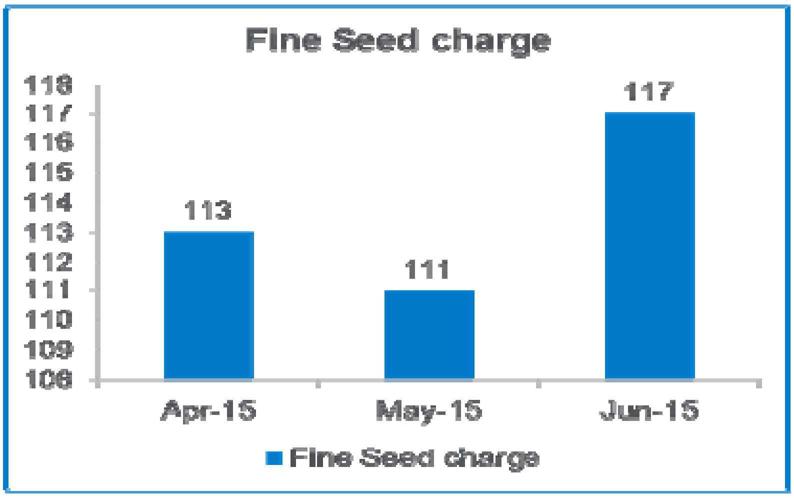

Figure 6. Average monthly fine seed charge (g/L).

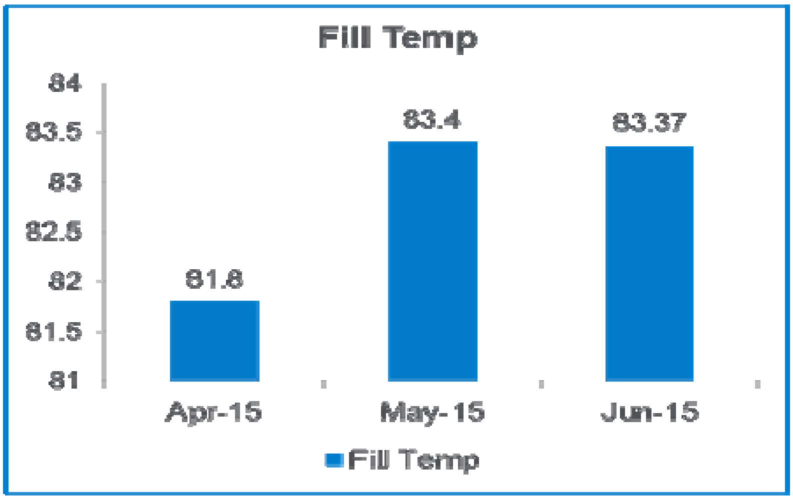

Figure 7. Average monthly fill tank temperature (°C).

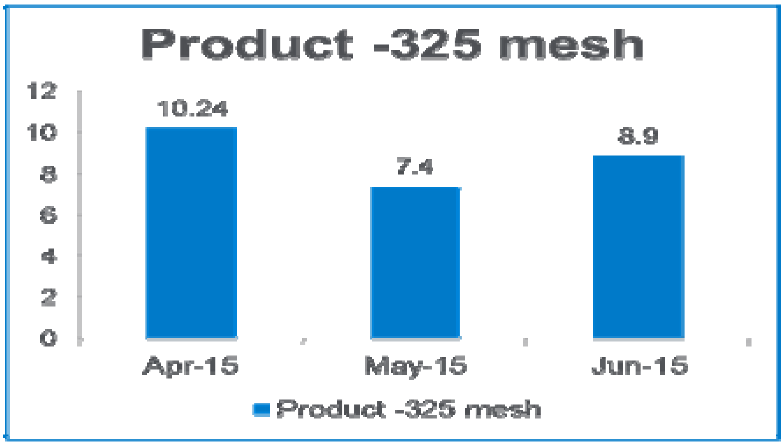

Figure 8. Average monthly % -325 mesh of trihydrate product.

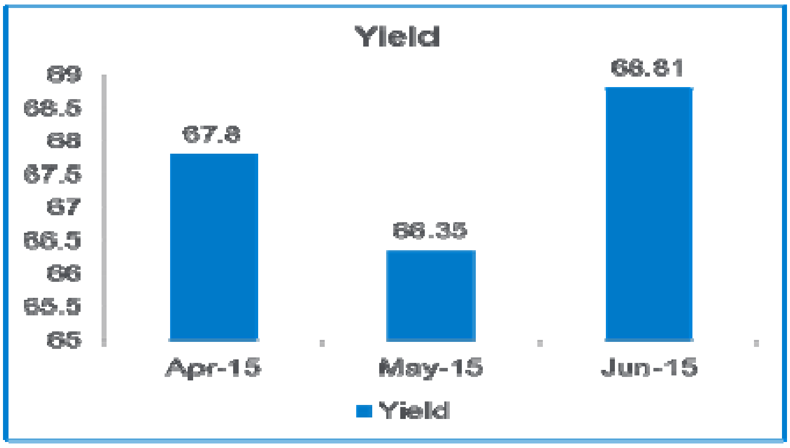

Figure 9. Average monthly yield (g/L).

Addition of CGMax has continued at the plant and optimization, assessment and monitoring of the impact on both yield and product size distribution (Phase 2 of the trial program) is ongoing.

4. Conclusion

CGMax is a new range of more effective CGMs that can be used to enhance alumina trihydrate product sizing and reduce fines in the precipitation circuit of Bayer plants. CGMax technology can be utilized as a remedial treatment to reduce unwanted fines. Alternatively it can enable plants to increase yield and improve efficiency by allowing manipulation of other process parameters (such as temperature, seed charge and supersaturation) to maximize yield – with addition of CGMax used as a separate control lever to regulate particle sizing.

Use of CGMax under plant conditions has demonstrated efficacy in helping to effectively control particle sizing and reduce outbreaks of fine material under conditions that would typically be unsustainable. CGMax is used on the Renukoot plant as an effective tool to help control product sizing and enhance process efficiency.

5. References

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