MAKING THE MOST OF HYDRATE GRAVITY CLASSIFIERS THROUGH THE USE OF HYDENS™ HYDRATE SOLUTION

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ABSTRACT

Hydrate classification is an important step of the Bayer process both to achieve acceptable product quality and to maximize liquor productivity. In some of its plants, Rio Tinto Alcan operates gravity classifiers. They allow very efficient size classification and are cost effective. However, it is a challenge to consistently keep high underflow solids concentration especially as tanks age between turnarounds. Flow behavior shifts from mass flow to preferential flow and eventually to funnel flow as more hydrate accumulates in the tank. This generally results in reduction of the underflow solids concentration, recirculating more spent liquor into the precipitation circuit and thereby reducing liquor productivity. Over the last few years, Rio Tinto Alcan has addressed this constraint with the development of the HyDens™ hydrate solution. The main benefit of this new technology is to increase productivity via withdrawal of higher density hydrate. This paper will present milestones in the development and validation of this technology. It will describe its development at Rio Tinto Alcan Vaudreuil alumina refinery, Saguenay, Canada and its industrial application at the QAL alumina refinery located in Queensland, Australia. Finally, the benefits will be quantified.

1. INTRODUCTION

Although in the last few decades new greenfield refinery projects have consistently chosne hydrocyclones for hydrate classification, several plants still rely on gravity classification for the separation of hydrate product, fine and coarse seed size fractions. Such classifiers usually consist of large diameter tanks where coarser hydrate particles settle and need to be pumped on to the next process stage. One objective of the operation of these vessels is to increase the underflow solids concentration of the hydrate slurry as much as possible to avoid recirculating large volume of relatively spent liquor. However, as feed flow rate increases and as the tanks age between turnaround, the hydrate starts accumulating along the walls and preferential flow results. Figure 1 shows the results of a simple laboratory simulation where the underflow was pumped normally. A large amount of hydrate remains settled in the tank and cannot be pumped out, reducing the efficiency of the classifier. The HyDens™ hydrate solution was developed to help correct this behaviour and to allow increased performance of hydrate gravity classifier. This technology was derived from the experience and knowledge gathered through the development of the bauxite residue solution as has been previously reported (Pucci et al. 2012). The patent for this new technology is pending (Peloquin et al. 2012)

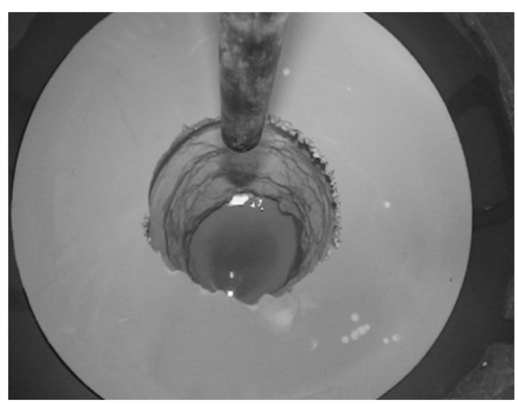

Figure 1. Pumping hydrate from a tank

2. EXPERIMENTAL

2.1 ARDC Laboratory

The development of the HyDens™ solution for hydrate applications started in the laboratory at Rio Tinto Alcan Arvida Research and Development Centre (ARDC). Figure 2 presents the laboratory setup used for the initial tests including a pilot classifier of 0.6 m in diameter and 1.6 m in height, fitted with the HyDens™ solution. Various feed pumps, buffer tanks and valves allow continuous operation of the classifier at various feed rate. Hydrate and liquor from Rio Tinto Alcan Vaudreuil alumina refinery were used for the tests.

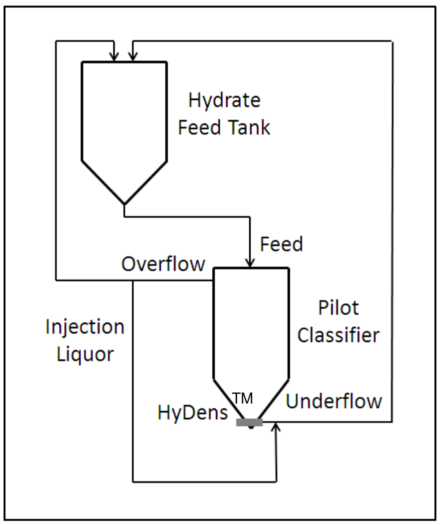

Figure 2. Laboratory setup to study hydrate movement in pilot classifier

2.2 Hydens Technology

In application, Hydens technology consists of solid displacement elements installed within the vessel for directing settled and/or settling solids from the wall or the base of the vessel toward the flow path of the slurry being extracted. To ensure efficiency, it has to be designed considering specific tank and operating parameters. Figure 3 is a top view of a pilot of the technology tested at CURAL.

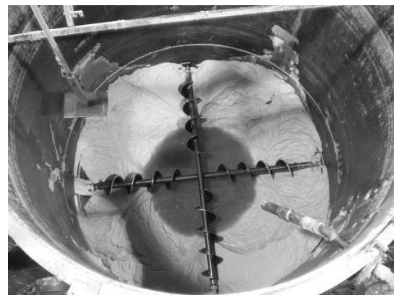

Figure 3. Laboratory scale HyDens™ classifier pilot

2.3 Secondary Classifier Pilot at CURAL

Larger scale piloting took place at the Centre Universitaire de Recherche sur l'Aluminium (CURAL) laboratory located at the Université du Québec à Chicoutimi (Saguenay, Québec, Canada). Figure 4 presents the pilot that was used. It is a 1/160th scale version (based on volume) of a typical secondary classifier used at the Queensland Alumina Limited (QAL) refinery. The pilot is 4 m in height and 4 m in diameter (at the top) with a 60° conical bottom and is equipped with the HyDens™ hydrate solution. The hydrate and adjusted liquor from Rio Tinto Alcan Vaudreuil alumina refinery were used. Again, several pumps and tanks were used to allow continuous operation of the classifier for extended periods. Instrumentation measuring flow rate, underflow solids concentration and hydrate accumulated in the tank were installed to monitor performance.

Figure 4. Secondary classifier pilot of at CURAL

2.4 Vaudreuil Industrial Prototype

Later developments of the technology were carried out by installing the HyDens™ hydrate solution on an industrial hydrate wash tank at the Rio Tinto Alcan Vaudreuil alumina refinery. This tank is cylindrical with a conical bottom at 30°. The wall height of the tank is 15.4 m and the diameter is 7.3 m. Typical underflow rate is 150 m^3/h.

2.5 QAL Industrial Application

The industrialization of the HyDens™ hydrate solution was done on an operating hydrate secondary classifier at QAL refinery and is shown in Figure 5. The tank is 26 m in height and 23 m in diameter. The cone angle is 60°. Typical feed flow rate is 1100-1500 m^3/h and underflow rate is 260-440 m^3/h. The HyDens™ hydrate solution was commissioned in April 2013 and industrial trials have been carried out since then.

Figure 5. QAL secondary classifier with the HyDens™ hydrate solution installed

3. RESULTS

3.1 Changes in Hydrate Movement When Using the HyDens™ hydrate solution

The objective of the initial tests was to improve the underflow solids concentration being pumped out of the classifier. Batch laboratory tests carried out at ARDC demonstrated the typical results reported in Figure 6. The HyDens™ hydrate solution allows operating the vessel with consistent and higher underflow solids concentration until the tank is empty of hydrate. For operation without HyDens™, the dotted line shows fluctuations and a reduction in underflow solids concentration as the liquor short-circuits more and more to the underflow; some hydrate remains in the tank at the end as seen in Figure 1.

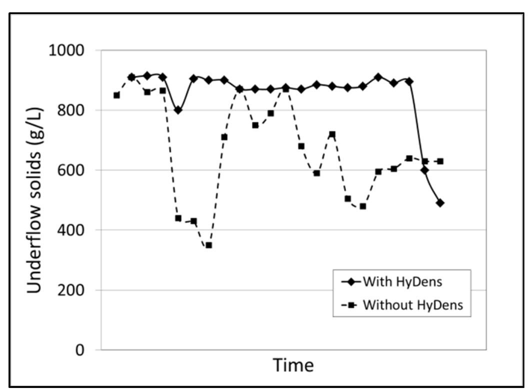

Figure 6. Impact of the HyDens™ hydrate solution in batch laboratory test

In order to achieve high underflow solids concentration, a minimum residence time is required for the hydrate to compact and consolidate. Since the HyDens^{TM} solution changes the movement of hydrate in the tank and thus the available effective volume, it is important to evaluate the impact of the residence time of the hydrate slurry on the underflow solids concentration. Figure 7 reports such results measured at ARDC. Note that the height of the hydrate bed has little effect. For a given underflow rate, the minimum required time has an impact on the equilibrium level of hydrate needed in the classifier.

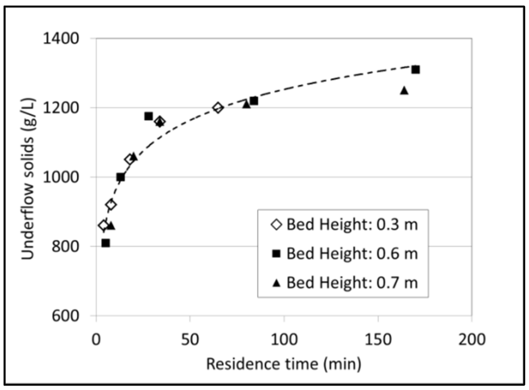

Figure 7. Impact of residence time on underflow solids concentration with HyDens^{TM} hydrate solution

The overall arrangements of the various parameters important for the HyDens^{TM} hydrate solution were studied using the Rio Tinto Alcan pilot at CURAL. Several runs were carried out simulating the complete operation of the classifier and investigating the impact on the underflow and overflow concentrations and classification efficiency.

3.2 Industrial Performance at Rio Tinto Alcan Vaudreuil Alumina Refinery

The HyDens^{TM} hydrate solution was fine-tuned allowing the design of an industrial unit that was installed on a hydrate wash tank at Rio Tinto Alcan Vaudreuil alumina refinery. This tank has now been operated for a few years. Typical underflow performance with the HyDens^{TM} hydrate solution on and off is presented in Figure 8. This graph shows results similar to those obtained at the laboratory scale and reported in Figure 6. For this application, the HyDens^{TM} hydrate solution allows operating the tank with a high and consistent underflow solids concentration at around 1050 g/L. When the HyDens^{TM} solution is not operating, the underflow solids go down and a rat hole forms in the hydrate bed. Bringing the HyDens^{TM} hydrate solution back in operation allows extraction of thick hydrate.

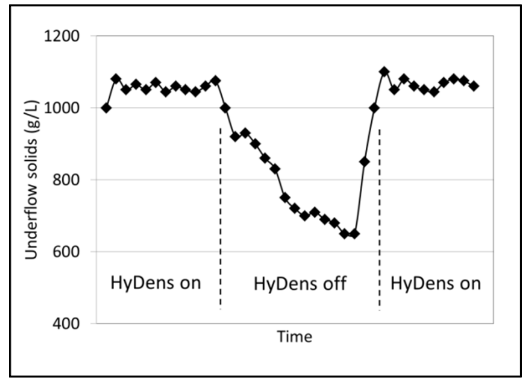

Figure 8. Impact of the HyDens^{TM} hydrate solution on operation of the Vaudreuil prototype hydrate wash tank

The design team used Finite Element Analysis (FEA) to ensure the structural integrity of the tank following the implementation of the HyDens^{TM} hydrate solution.

3.3 QAL Validation Campaign

It was recognised that QAL could benefit from the installation of the HyDens^{TM} hydrate solution in their secondary hydrate classification circuit, as it had the potential to provide a more cost effective debottlenecking compared with high capital options of thickening cyclones or seed filters. Figure 8 presents a long term summary of the underflow solids concentration achieved before and after commissioning of the HyDens^{TM} hydrate solution. Over the course of the period with the HyDens^{TM} hydrate solution in operation, several parameters were tested and this is reflected in the variation in performance. The maximum in underflow solids that was demonstrated is ~900 g/L solids. Due to a limitation on the downstream systems, the full ability to thicken the classifier underflow was limited. Data from the initial period suggests significantly higher density slurry could be achieved with debottlenecking of the process from the underflow point onwards. A conservative average gain obtained with application of the HyDens^{TM} hydrate solution to the existing equipment is 170 g/L solids (going from 580

g/L to 750 g/L). During operation of the tank, overflow clarity was continuously monitored. For typical operating conditions, the HyDens^{TM} hydrate solution does not alter the overflow clarity.

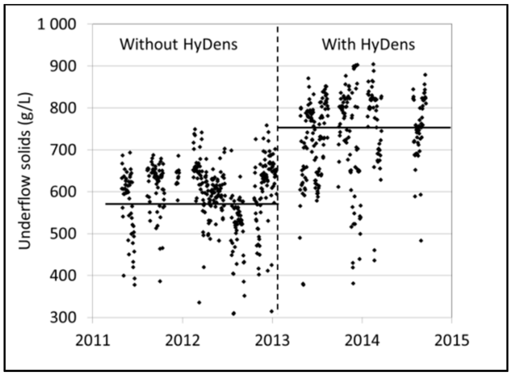

Figure 9. Summary of underflow solids performance obtained with and without the HyDens^{TM} hydrate solution on a QAL secondary hydrate classifier

Currently, the HyDens^{TM} hydrate technology is operated by the plant personnel with only a high level follow-up from the development team. Business case evaluation of the application of the technology to other classifiers in the plant is on-going.

4. TECHNICAL ADVANTAGES

4.1 Gains in Underflow Solids

The above results demonstrated the gain in underflow solids concentration achieved by the HyDens^{TM} hydrate solution. Depending on the classifier mass loading rate, the particle size distribution of the hydrate, the liquor characteristics (density, viscosity) and the presence of impurities (e.g. oxalate), the performance may vary. For classification applications where the underflow solids are recirculated back as seed to the precipitation circuit, any increase in the solids concentration directly translates to a decrease in the volume of spent liquor recirculated back thus increasing the precipitation circuit productivity and production. Additional positive impacts on energy and soda usage are also observed. Such a preliminary evaluation for the secondary classification circuit of QAL was carried out and is reported in Table 1. Assuming an alumina selling price of 300USD per ton, the value at stake varies from 105 million USD/year to 150 million USD/year. Of course, a more complete economic analysis taking into account the cost of the technology and the presence of bottlenecks in other areas of the plant is needed. Furthermore, application of the HyDens^{TM} hydrate solution to the primary classification circuit also needs to be evaluated.

Underflow Solids Increase	Production Increase	Value at Stake
g/L	kt/y	M USD/y
170	350	105
300	500	150

Table 1. Value at stake for application of the HyDens^{TM} hydrate solution to the entire secondary classification circuit of QAL

4.2 More Active Hydrate Bed

An additional benefit of the HyDens^{TM} hydrate solution is the more active hydrate bed that is caused by better movement of hydrate in the tank. Figure 10 presents a thermal image from the tank at QAL with the HyDens^{TM} hydrate solution in operation. Notice the relatively warm temperature for the bottom of the tank indicating a well formed but moving hydrate bed. The HyDens^{TM} hydrate solution allows continuously extracting the hydrate from the tank and limits any accumulation that would otherwise cool off to ambient temperature over time. Hence, although the tank is operated with a higher underflow solids concentration, the turnaround times are not negatively affected.

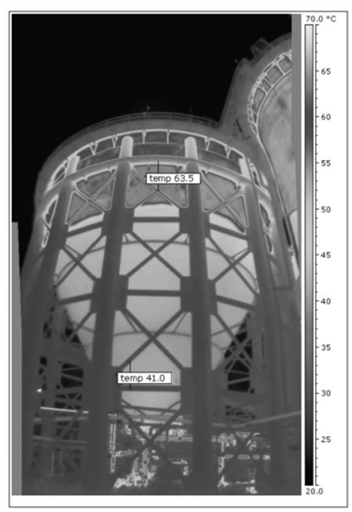

Figure 10. Thermal image of QAL secondary classification tank with the HyDens^{TM} hydrate solution

5. CONCLUSIONS

The HyDens™ hydrate solution can improve significantly the performance of gravity classifiers. HyDens™ was first developed in the laboratory before being piloted at a 1/160th scale. This allowed fine tuning of the various design elements before going to an industrial prototype scale. At this scale, additional challenges were identified and solved before moving to an industrial application. In this application, increases in underflow solids concentration between 170 and 300 g/L solids were demonstrated. Assuming no other bottlenecks are present, this could translate to potential production improvement up to 500 kt of alumina/year. The HyDens™ hydrate solution is applicable to any slurry tank where increasing the solids concentration could bring value. Typical examples are hydrate wash tank, primary or secondary hydrate classifiers, hydrate feed tank, etc.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Boivin, A., Hatzikyriakidis, K., Labrum, D., Peloquin, G., Pucci, A., Rousseaux, J.M., HyDens™ Technology Solutions Performance and Industrial Applications, Proceedings of the 10th AQW, Perth, 2015.

Pucci, A., Ferland, P., Peloquin, G., 2012, Rio Tinto Alcan Journey in Solid-Liquid Separation, Proceeding of the 19th ICSOBA, Bélem, 2012.

Peloquin, G., Larouche, A., Boivin, A., St-Laurent, M., Girard, R., Simard, G., 2012, Apparatus and method for refining a process liquor by gravity settling, WO 2012/019287 A1 application filled 16.02.2012, patent pending.

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