NEW THICKENER WITH THICK PASTE REMOVAL SYSTEM

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Abstract

The objective of most thickeners is to produce mud at the highest possible solids fraction in order to improve the separation efficiency. Extracting this dense mud from a thickener can be challenging and operation at high underflow rate is often causing channelling where liquor is short circuiting to the underflow. A new paste removal system that allows extraction of very thick mud at high flow rates was designed and tested in our laboratory. It consists of a device that mechanically extracts the mud out of the thickener and brings it to the underflow pump. Consistent operation with red mud at up to 54% solids was obtained in our laboratory. These results led to the development of a 3-m diameter flat-bottom pilot thickener fitted with the new paste removal system. The system is described and typical results are presented.

1. Introduction

Over the last few years, significant work has been carried out in our research centre to study red mud flocculation (Peloquin *et al.*, 2005a) and compaction in thickeners (Peloquin *et al.*, 2005b). Some of this work indicated that operational problems are often related to the difficulty of extracting red mud at high solids fraction out of thickeners. To allow pumping of such high solids fraction mud, the concept of a screw discharge underflow system was proposed (Peloquin *et al.*, 2007) and tested in our laboratory. Following preliminary good results obtained with a small flat-bottom pilot thickener fitted with this system, it was determined that a larger pilot thickener was needed to validate the performance of this thick paste removal system at a scale more comparable to that of industrial thickeners. This paper presents results from the preliminary evaluation of that performance. The evaluation of the system operating with high solids fraction mud and its ability to control ratholing are presented. The impact on mud rheology is discussed. The technical advantages are later presented.

2. Experimental

Tests were carried out in one of the Rio Tinto Alcan alumina refineries. It is installed in parallel to the last washer of the mud circuit. The pilot thickener is a flat-bottom cylindrical tank with a 3-m diameter and is described in Figure 1. The thick paste removal system is composed of two concentric helicoidal screws of different diameters. It is installed at the bottom of the thickener. The system has the possibility to operate the two screws simultaneously. Tests can also be run with the two screws inactive. The screw system removes the mud from the bottom of the thickener and brings it to a holding box from where it is pumped, using a centrifugal pump, back to the underflow pipe of the plant last washer. The mud feed to the pilot thickener consists of two lines that take dense mud from the underflow of the plant last washer and liquor from its overflow. The two streams are mixed together through an inline mixer. The target feed solids fraction and feed flow rate are 10% and 34 m^3/h. They are controlled by two automatic valves coupled with a flow meter and a density meter. The flocculant is pumped from the plant by a positive displacement pump and is added directly to the off-centred feed well of the pilot thickener at a dosage of ~60g/t. The underflow solids fraction is measured with a density meter.

3. Results

Two commonly encountered issues in thickener operation are the removal of very high solids fraction mud and control of the ratholing effect. For tested mud, the first one can be observed when the solids fraction of the mud reaches around 52%. Ratholing is characterized by low solids fraction mud at the underflow although high solids fraction mud is present in the thickener. It is affected by mud residence time, mud bed height, underflow pump rate fluctuations, flocculant dosage and underflow configuration.

To evaluate the impact of the thick paste removal system on these two issues, the first step was to select operating parameters that would display such behaviour. This was done by running tests from a combination of mud levels, mud residence times and feed mass fluxes. The solids fraction at the underflow was measured when it reached equilibrium. Note that during each test, the conditions were kept constant for about three times longer than the target mud residence time.

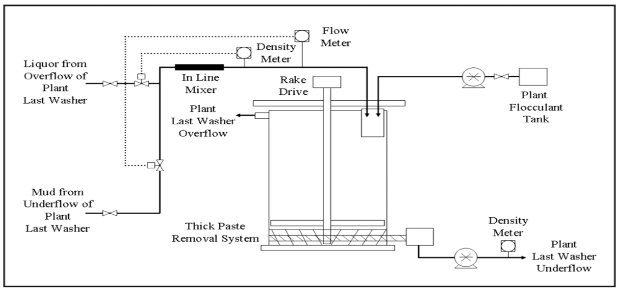

Figure 1. Diagram of the screw thickener with the thick paste removal system and auxiliary equipment

Since red mud is shear thinning and thixotropic, its rheology is affected by the amount of shear and by its history. By extracting high solids fraction mud without relying on a centrifugal pump, the thick paste removal system allows to obtain mud at high yield stress. Samples of red mud extracted with the system were collected and yield stress measured.

3.1 Removing high solids fraction mud

Tests to determine the ability of the screw to efficiently remove high solids fraction mud were performed with a high mud bed height. Feed mass flux was 6.7 t/m^2/day. The set point of the underflow rate was 2.2 m^3/h. These conditions easily generated high solids fraction mud at the underflow. In order to characterize the effect of the screw, its rotation rate was progressively decreased once equilibrium was reached. Data are presented in Figure 2.

For the first few hours, the system was run with stable conditions until equilibrium was reached. For these conditions, the underflow rate, the screw velocity and the underflow pump velocity were all stable. The velocity of the screw was first increased at 7:30. The underflow pump and the underflow rate were not affected. The screw velocity was then progressively decreased to zero over a period of 90 minutes. The underflow rate was not affected until ~8:30 when it started to decrease. This occurred at 18% of the screw rate velocity. From this point on, the underflow rate decreased progressively. In an effort to keep the underflow rate constant to the target set point, the pump velocity was increased by the control system but the underflow rate continued to decrease in function of the screw rate until it reached almost 0 m^3/h when the velocity of the screw was 0%. The pump was unable to remove the high solids fraction mud from the thickener without the action of the screw. Throughout the test, the underflow solids fraction remained constant at ~54%. From the previous result, it is clear that the thick paste removal system helps removing high solids fraction mud out of the pilot thickener. The hypothesis explaining the action of the screw is based on the amount of mud moved by the screw compared to the amount of mud required by the underflow pump to achieve its target flow rate. As long as the screw brings enough mud to the pump, the target flow rate is achieved with the pump running at moderate velocity. As the velocity of the screw is reduced, the pump is starving and increases its velocity to try to maintain the target flow rate. However, since the mud is very viscous, the flow rate cannot be obtained only with the suction of the pump.

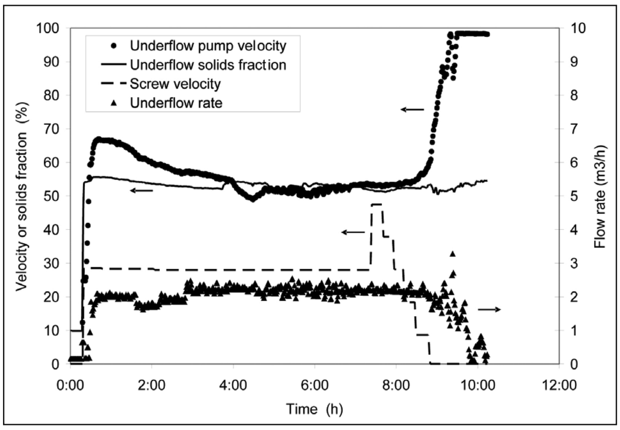

Figure 2. Impact of the screw velocity on the underflow of the thickener

3.2 Control of ratholing

The screw performance was evaluated under two conditions that generate ratholing. For the first condition, operational parameters were kept constant and tests were carried out with the screw system both in operation and off operation. Tests were performed with a low mud bed height and a low mud residence time. The feed mass flux was 24 $t/m^2/day$. Part of the screw was blinded to simulate operation of a shorter screw. The tests were carried out during three days. All operational parameters were kept constant except the operation of the screw. During the first and the third day, the screw was in operation. During the second day, the screw was not in operation. Underflow solids fraction against time is presented in Figure 3. The average solids fractions obtained for the tests run with the screw in operation are higher than for the test run with the screw stop. The difference is approximately 6% and is significant. We can also observe that for the period where the screw was not in operation, the underflow solids fraction was significantly less stable.

For the second evaluation, the impact of a rapid change in the underflow rate was studied for conditions with the screw in operation and off operation. Tests were performed with a low mud bed height. The feed mass flux was 6 $t/m^2/day$. Part of the screw was also blinded. After equilibrium was reached, the underflow rate was quickly increased from 2 m^3/h to 10 m^3/h for about two hours and brought back to 2 m^3/h afterwards. Results are presented in Figure 4. For both conditions, there is a decrease in the underflow solids fraction when the underflow rate is suddenly increased. The decrease is significantly larger (-6.8%) for the condition when the screw is not in operation than for the condition when the screw is in operation (-3%). This shows a better control of ratholing with the operation of a screw.

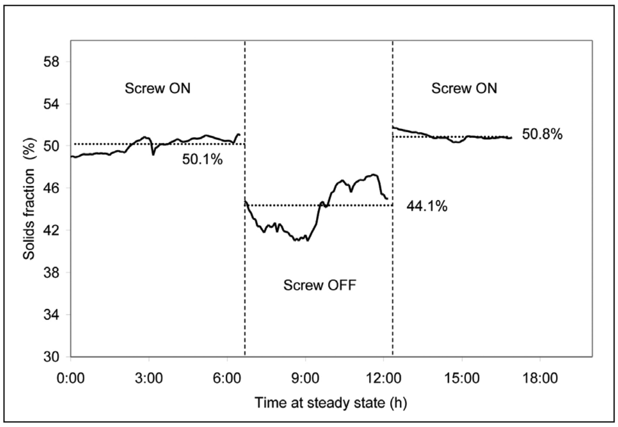

Figure 3. Underflow solids with the screw on and off

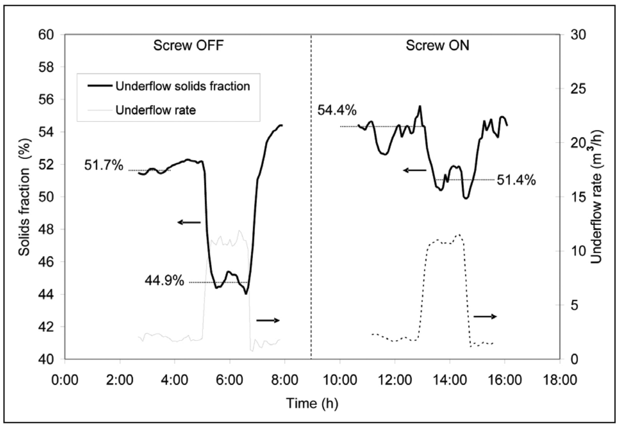

Figure 4. Impact of the underflow rate on underflow solids fraction with the screw off and on

3.3 Mud rheology

Several samples of red mud were collected in an effort to measure their yield stresses. Figure 5 presents a close-up view of the underflow system. The locations of sampling points are indicated in the figure. Sampling point 1 is located at the outlet of the holding box just before the underflow centrifugal pump. Sampling point 2 is located at the end of the line, about 15 m downstream of the underflow pump. Yield stresses were measured with a Haake VT550 rheometer and a vane FL100 sensor. Measurements were done at room temperature. Data are reported in Table 1. The removal of mud with the action of the screw occurs at a much lower shear rate than the pumping of mud with a centrifugal pump. Hence, the yield stress of the mud taken before the pump is significantly higher than that of the samples taken after the pump. This behaviour is valid for moderate solids fraction and for higher solids fraction mud. The thick paste removal system allows removal of mud out of a thickener while keeping the yield stress significantly higher. This can have a large impact in terms of the stacking capability of the mud.

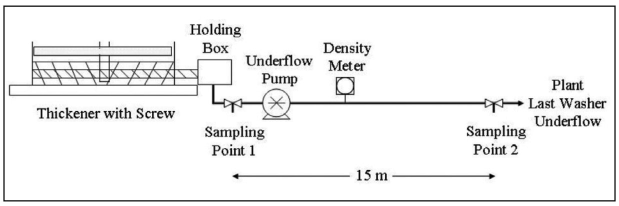

Figure 5. Sampling points at the underflow of the pilot thickener

Table 1. Yield stress of mud at the underflow of the pilot thickener

Sampling Date	Solids Fraction	Yield Stress at Sampling Point 1	Yield Stress at Sampling Point 2
	%	Pa	Pa
13 February 2008	50.5	158	45
18 February 2008	53.0	247	95

3.3 Longer term performance

Longer term performance was measured for ten days and compared to the performance of the plant last washer. Both were operating with the same mud, liquor and flocculant. The plant last washer is a deep cone washer. Normal plant constraints, like volume control, availability of wash water, etc. were effective for the operation of the plant last washer. Mass fluxes were 10 t/m^2/day for the plant washer and 19 t/m^2/day for the pilot thickener. Figure 6 presents the underflow solids fraction for both thickeners. The average underflow solids fraction is higher by 4% for the pilot thickener although it is operating at about twice the mass flux compared to the plant washer.

4. Technical advantages

The impact of the installation of a thick paste removal system in the last washer of the alumina refinery was studied. Solely the impact of the increase in solids fraction at the underflow of the washer was considered. Based on data in Figure 6, the installation of a screw discharge underflow system would increase the average underflow solids fraction from 48% to 52%. The increase in underflow solids fraction translates to a significant reduction in soda and alumina losses.

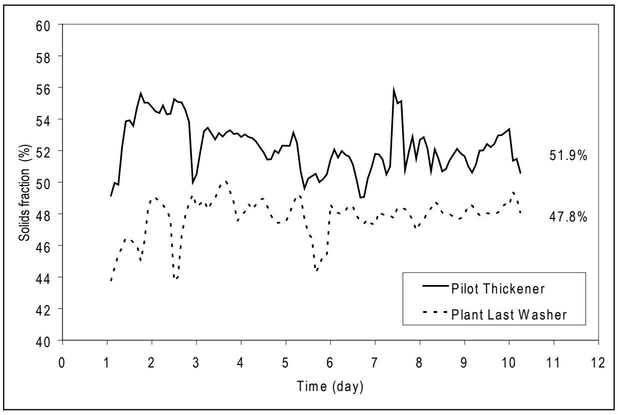

Figure 6. Comparison of underflow solids for the pilot thickener and for the plant last washer

The increase in the last washer underflow solids fraction also corresponds to a reduction of the amount of liquor being sent to the mud disposal site. This, in turn, reduces the amount of water that needs to be evaporated in order to consolidate the mud. It also reduces the amount of mud farming work that needs to be done in order to speed up consolidation. The monetary impact on the mud disposal site is also significant.

A mud with a higher solids fraction exhibits a higher yield stress. This allows stacking of that mud at a steeper angle, thus maximizing the usage of the mud disposal site.

5. Conclusions

The thick paste removal system allows taking high solids fraction mud out of a flat bottom thickener without relying on the suction of a centrifugal pump. In doing so, it reduces any liquor channelling to the underflow point and thus allows maintaining high underflow solids. This advantage is also maintained at high underflow rate. The thick paste removal system allows production of mud at a very high yield stress. Continuous operation for ten days was achieved and showed an improvement of about 4% solids on the underflow solids fraction compared to the last washer of the plant.

Our analysis shows that there are significant advantages to install a thick paste removal system in the plant last washer. A detailed evaluation is currently underway to examine the potential of such a system in other refineries.

References

Peloquin, G., Simard, G., Boivin, A., Dufour, R., Lemyre R. and Carruthers, A. 2005a, 'Apparatus for and method of settling of mineral slurries', US Patent 6936178.

Peloquin, G., Bui, R.T., Kocaefe, D. and Simard, G. 2005b, 'Modélisation mathématique de la décantation de la boue rouge', *Canadian Journal of Chemical Engineering*, vol. 83, no. 3, pp. 458-465.

Peloquin, G., Dufour, R., Carruthers, A. and Puxley, D. 2007, 'Apparatus for production, withdrawal and transfer of highly viscous slurry', Patent application WO 2007/022622A1.