

Sustainable solids – liquid separation in mining and mineral industry with solid bowl decanter

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Abstract

Traditionally, a number of different solid-liquid separation techniques have been used in the mining and mineral processing industries. This has mainly been dominated by a number of conventional filter technologies as well as gravity based separation principle. During recent years, modified technologies in solid bowl decanter have proven clear benefits in using decanter centrifuges in, e.g., tailings treatment, even with very fine particles. In the alumina industry, the first tests also showed the benefits of improving sustainability with decanter centrifuges in a number of applications. With reference to several installations in mining and mineral applications as well as to the recent initial test in alumina industry, this paper will discuss how modified deep pond decanter centrifuge proved that the erosive and corrosive environment in which it was mounted (a washer stage) did not create operational problems. This technology will be further tested before final optimisation of the internal design to develop a dedicated full scale decanter centrifuge for alumina industry. The test work will also include other parts in the alumina production process.

Keywords: Tailings; alumina; washer stage; solid bowl decanter centrifuge; recovery.

1. Introduction

For most, if not all Mining & Mineral industries there are several processes where the solid - liquid separation plays an essential role in making the process viable and securing a profitable business for the operation of the plant.

This being in the mining/beneficiation part, the extraction and concentration, or in the purification and metal recovery part of the process. Several steps of solid – liquid separation are located in these process steps, tailings treatment being the largest one, but also several stages are seen in thickening, Crud treatment, etc..

Historically, this separation has taken place in either gravity thickeners followed by disposal e.g. tailing in dam, or by conventional filter technology like plate and frame or belt filter technology. This has been the traditional concept of disposal of tailings slurry to emplacement areas where the solids proportion of the slurry consolidates over time and some of the released water at the dam can be recovered and recycled.

But there is a growing interest in alternative technologies that can deliver improved water recovery, smaller footprint of tailings disposal areas, better rehabilitation opportunities or a combination of these things.

These alternative technologies have been looked at as a single tailings management solution, or as something added to traditional tailings dam disposal. The key considerations in selecting the components of a tailings disposal system would include, among other things:

- Available land area for disposal in either single or multiple disposal locations;
- Topography of selected sites for containment volumes and sensitivity to holding capacity for the life of mine;

- Considerations of storage volume and consolidation time with respect to the normally desirable progressive rehabilitation of tailings disposal sites;
- The opportunity to dispose of fine reject with coarse reject, which may influence the rate of consolidation and thereby present an opportunity for faster rehabilitation;
- Remoteness of the disposal site;
- The impact of future expansion or containment;
- The extent to which water recovery is required (at the plant or dam site) and whether maximizing the water recovery or the ability to dispose of excess water is the primary aim — and whether this aim is required across the life of mine;
- The effect of high recycle water rates on accumulation of dissolved salts and effects of corrosion;
- Capital costs of the entire system;
- Operating costs of the entire system;
- Reliability and stability of the system, particularly the tailings chemistry, particle sizing
- Tailings generation rates;
- Stability of spoil dump that includes co-disposal.

This paper will present how modern solid-bowl decanter centrifuges can be used as an alternative to both traditional tailings dam disposal technique that are in use or that have been used and to other filtration technologies used throughout the Mining & Mineral solids – liquids separation processes.

2. Solid bowl decanter centrifuge

Solids bowl decanter centrifuges were popular in the Mining & Mineral industries in 1980's and competed directly with belt press filters for e.g. tailings dewatering. From the early 1990's the use was reduced because they could not cope with increasing production rates. In the last few years several modified technologies have been implemented to the point where today, tailings treatment plants with Solid bowl decanter centrifuges with capacities above 1 200 dry ton per hour of treatment capacity can be seen.

Centrifuges have developed from tens of liters per hour at hundreds of rpm in the late 19th century to what we have today. 300 m³/h at up to 8 000 rpm and numerous applications including the separation of cream from milk, purifying beer and wine, cell separation in the biotech industry and several Mining and Mineral applications.



Figure 1. Decanter centrifuge.

For separation applications with comparatively high solids loading, the decanter centrifuge is the most suitable. Decanter centrifuges were originally developed for industrial applications in the late 1940's. Its design is based on a horizontally driven bowl to induce accelerated sedimentation.

This, combined with a conveyor running with a speed differential to the bowl, transports separated solids up a conical beach and discharges solids in the form of a dry cake. The clarified liquid phase is discharged at the opposite end of the centrifuge over weir plates.

2. Basic principles

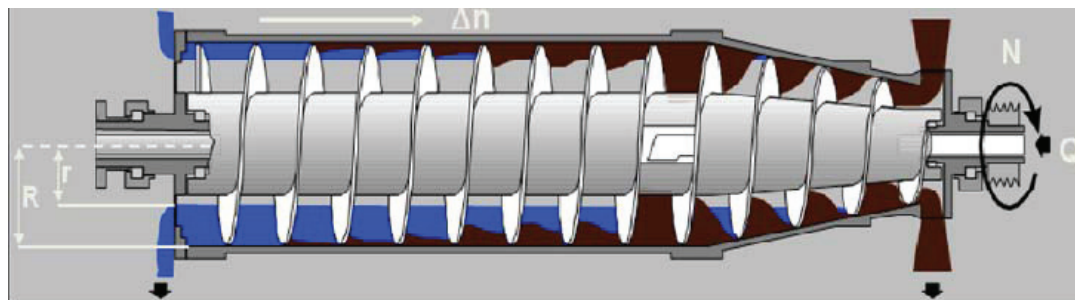


Figure 2. Decanter cross-section.

Process Parameters

- Feed rate (Q)
- Particle size (polymer addition)
- Viscosity (heating)

Decanter design

- Bowl speed (g-force)
- Conveyor differential (Δn)
- Pond depth (R-r)

Process parameters such as feed rate, particle size and viscosity, together with centrifuge configuration (for example bowl speed), conveyor to bowl differential speed, liquid pond depth and cone beach angle will directly affect separation performance and solids removal.

3. Technology developments

Sigma factor (developed in 1948) was used in the very early days of decanter development, where sedimentation was the only factor been considered and any practical information from various applications was very limited.

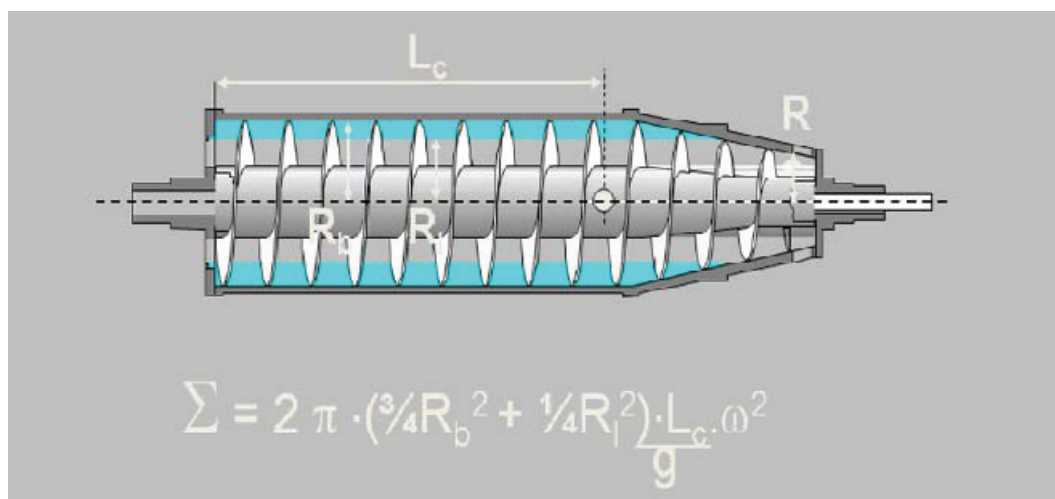


Figure 3. Sigma factor & centrifuge performance.

Despite limitations of this formula it has been used for a large number of old designs. Some of these decanter centrifuges have been upgraded, but they still have a very large radius to the liquid surface as the sigma formula indicates in fig. 3. As it is noted, the formula states that this should give a high capacity.

In reality, a larger radius to the liquid surface will reduce the capacity of a decanter. In the late 1980's a number of studies revealed the limitations of the Sigma factor and in general it was realized that the solids handling capacity was the real limiting factor for most decanter applications.

Since then the main focus for decanter development has been to improve solids handling capacity. In this context, solids handling capacity means two things; the capability to achieve high cake dryness and to discharge large volumes of cake at the same time.

Alfa Laval for example, a leading supplier of decanter centrifuges, switched focus to solids handling ability as a general guide to equipment design. The result was a clear increase in solids handling ability in a variety of processes, from mineral industry, drilling mud treatment in the Oil & Gas industry to fish and meat dewatering. Again, using the Alfa Laval products as an example, a couple of important designs demonstrate the development since then. The P2 Alfa Laval decanter – widely used for the last 10 years within the chemical, COG & Steel, Pulp & Paper industries, in many cases runs on slurry where the main goal is to discharge as much solids as possible, at a dryness often directly proportional to the efficiency of the plant operation.

Often the solids within these industries are relatively dense, so residence time is not always the most critical factor. The shallow cone angle allows the solids to travel up the beach more easily for high solids removal.

General belief would suggest designing such a decanter with a large radius to the solids discharge ports, but instead the P2 decanter has the same radius to the solids discharge ports as a deep pond decanter and the deeper pond is used to increase the scrolling capacity of this unit. All internal solids passages are designed for high solids handling capacity and the small solids discharge radius has not limited the capacity.

In tailings and most other separation applications within the Mining & Mineral industry, the demand is to achieve a dry cake, clean liquid phase and still operate at a high solids load (tonnes/h). To capture the fine particles polymer is often required. This will give solids with a cake like behavior and will not readily allow liquid to drain off. In order to get a dry cake, it is necessary to operate with a deep layer of solids and with low differential speed.

To design a suitable machine for high solids Mining & Mineral applications involves a lot of detailed knowledge about cone angles, flight pitch variation and inclination, pond depth, G-level and differential speed coupled with the convey ability of the solids as a function of dryness.

The optimized decanter design is based on experience gained in tailings applications – testing and full scale plants since 2008 and recently resulted in the 3rd generation of Process Decanter, the P3 Decanter specifically made for Mining & Mineral industry.

Controlled levels of shear are needed for effective distribution of the polymer in the feed to the decanter. Low shear in the decanter ensures dry cake and highest quality concentrate. High cake discharge radius result in a limited possibility for deeper pond depths and separation performance.

A large liquid surface radius will automatically introduce a high shear in the decanter feed zone and the lower pond depth will limit the solids handling capability, particularly with flocculated solids. Incidentally, the larger discharge radii on both solids and Centrate discharge areas will also cause high shear and hence high wear in those areas. It is therefore predictable that discharging both solids and liquids at smaller radii will reduce discharge velocities, limit wear in those areas and reduce power draw as a result.

4. Handling wear effectively

The nature of a separation process with high solids loading and centrifugation will promote the possibility of increased wear. In the design of the decanter there is a trade-off between component life and the use of higher cost, wear resistant materials to limit wear. The choice of materials must meet acceptable component life and cost of ownership for the centrifuge. Using material inserts in the known wear locations help to meet market expectation. An example of this is the use of tungsten carbide wear liners in the decanter feed zone. The benefits of this are to limit material change only to the affected area and to keep the time necessary for repair to a minimum.

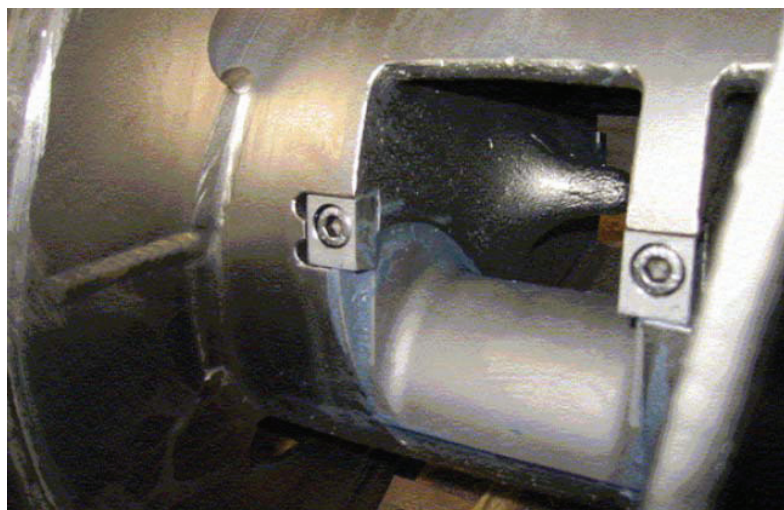


Figure 4. Erosion protection with inserts in the decanter feed zone.

Wear due to the differential speed between the decanter conveyor and bowl can be effectively handled with the simple inclusion of ribs, welded to the bowl of the decanter centrifuge.

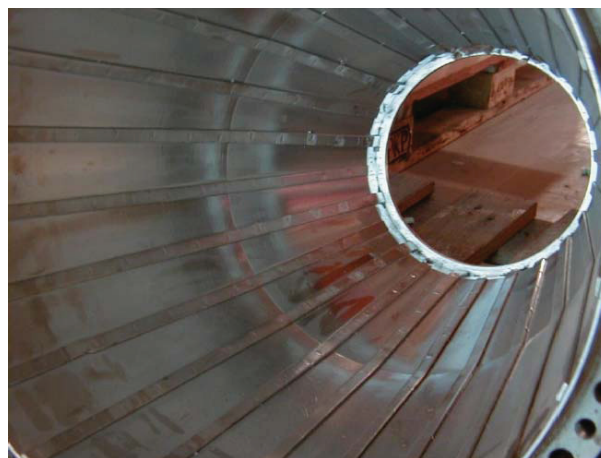


Figure 5. Ribs in the centrifuge bowl.

Solids naturally collect between the ribs providing a layer of protection. The positive effects of this design are increased wear protection of the bowl and conveyor, and improved solids transportation. For added protection of the conveyor, tungsten carbide tiles are attached to the conveyor flights.

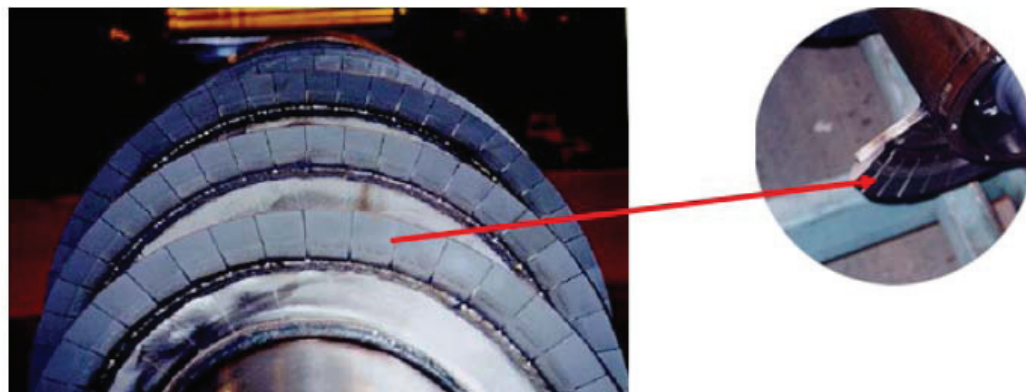


Figure 6. Tiles protect the conveyor flights.

5. Handling corrosion effectively

A number of the applications within Mining & Mineral industry are known for working with corrosive components. This could be saline tailings from natural saline deposits in the ore or it can be corrosive chemicals from (for e.g.) the extraction process. The obvious solution is to utilise a high corrosion resistant alloy on all process wetted parts in the decanter centrifuge. However, this will often be a trade off in investment cost as building rotating bowl and conveyor in a high grade alloy will not only have a major impact on the direct investment cost but also put extreme high demand on the manufacturing of the castings of the rotating components.

A high grade Duplex Stainless Steel material has proven on many Mining & Mineral applications to be sufficient as the conditions inside the decanter is close to inert, i.e. no oxygen present as an ingredient for the corrosion process.

A Cleaning In Place system – capable of securing a proper cleaning of the wetted parts in, as well as outside the rotating parts, prior to longer stand still periods is equally important as a correct material selection

6. Centrifuge control

With a fixed differential speed decanter a reduction in the solids loading in the feed to the centrifuge will cause a reduction in cake dryness. With most Mining & Mineral solid – liquid applications (for e.g.) tailings treatment, the centrifuge will typically be solids limited, so an increase in solids loading in the feed to the centrifuge will increase the risk of over-torque on the unit. Monitoring the torque between the bowl and conveyor and automatically varying their differential speed make it possible to maintain the optimal performance of the centrifuge and consistent cake dryness. Variable differential speed control will also protect the centrifuge against the possibility of overtorque.

7. Process vision for mining and mineral applications

As an example of an application to be discussed in this paper, red mud separation was selected. Tests have been carried out at two different Alumina plants as a first validation process in proving the use of decanter centrifuge within the Alumina process. The results below refer to a test carried out at Companhia Brasileira de Alumínio (CBA) site located at Alumino, Sao Paulo (Votorantim Metals) during Q1, 2015

Step 1 (Figure 7) in the process was to investigate a Decanter centrifuge as a replacement for the current dewatering technology after the final washer, red mud dewatering by Rotary Vacuum Filter, in the “red side” washer stream. A test was done without the use of polymer. Dewatered cake dryness of 69 – 71 % was achieved but with a relative poor recovery rate (70 to 80 %). As such it is not applicable due to risk of recycling fines back to the process with risk of affecting washer efficiency.

Step 2 (Figure 7) was to do same test, but with a polymer addition. Two different polymers were tested, although none of them were actually intended for Decanter centrifuge use. Cake dryness was slightly lower at 67 to 69 %, as much more fines “catch” but an improvement in recovery was immediately seen with a recovery rate up to 99 %.

A further test is required to conclude on performance. A dedicated polymer for higher shear stresses, the ones used were polymers intended for low shear stress in a gravity thickener and at a concentration not optimized for decanter use, needs to be carried out to optimize the polymer consumption further and still produce a cake which is well suited for dry stacking

Step 3 (figure 7) is now planned to be carried out with the objective to prove in what way Decanter centrifuge can be a reliable alternative to today's gravity based washers. Washers in the Alumina process is known to be extremely maintenance intensive due to the high scaling that can take place.

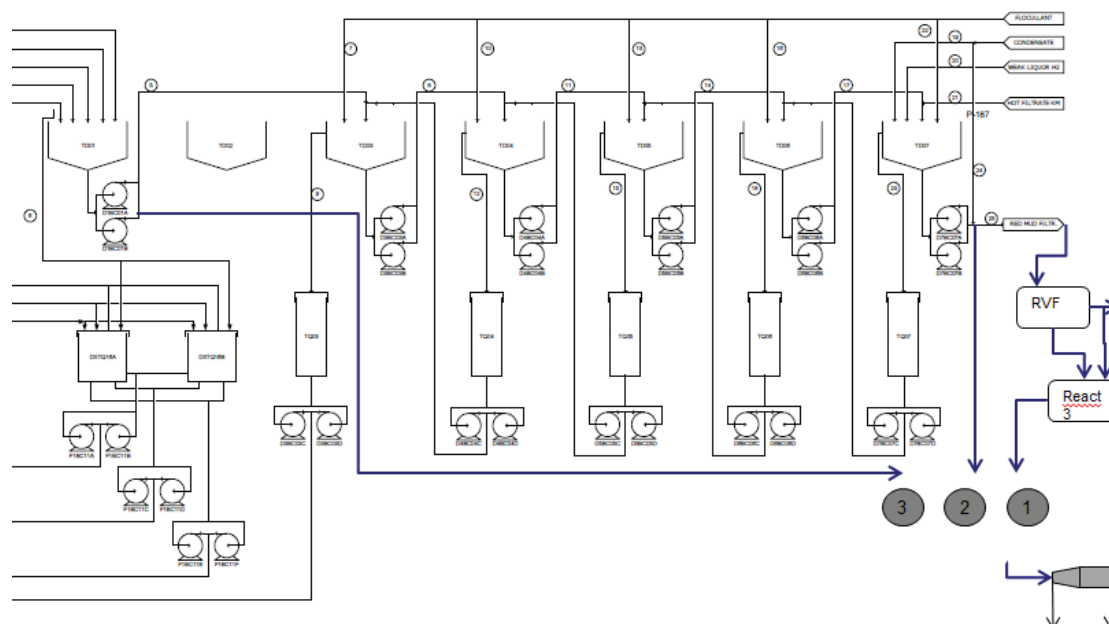


Figure 7 – Locations for test carried out (1) and (2) and scheduled to take place (3).

8. Conclusions

With reference to the last 5 years of test and full scale references in the Mining and Mineral industries, it has been proven that the solid bowl decanter is “back in the game” again. If modified deep pond technologies is used, clearly addressing the need for high solids transport and not only efficient separation capabilities, and combining it with excessive wear protection against the highly abrasive slurries processed, references show that it is an economically viable solution.

Opportunities to prove this by field testing is critical, as each mining industry, and in many cases each mining site, is different. Alumina is one of these industries where initial tests have been made with very positive first hand observations.

9. References

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