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Most common problems in thickener operations

We have discussed in early articles the strategies to optimize water consumption (part 1 and part 2) and learned the vital role that thickeners play in the optimization of the water recovery process. In this article we will explore the most common Luís Bernal Venegas, Consultor Externo de procesos de A-S CHILE EGSA
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Thickeners are continuous sedimentation equipment used to perform solid-liquid separation in finely ground slurry ore as mineral concentrates or tailings. Depending on the configuration of the plant, the type of mineral and the thickener technology, the recovery of water can vary between 65% to 95% of the process water recirculates, as shown in figure 1.

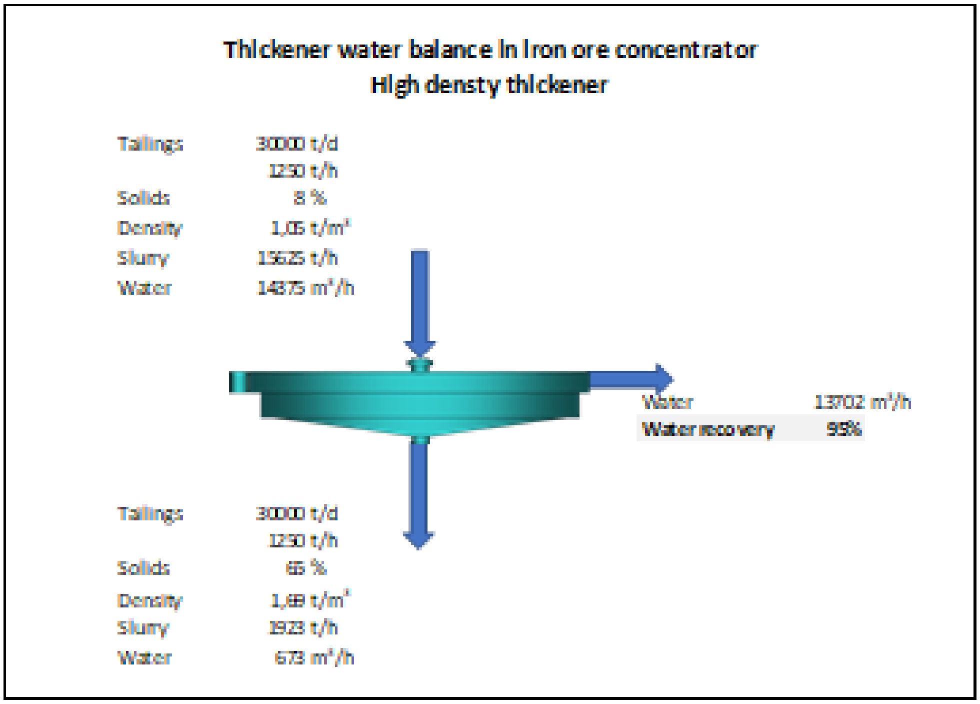

Figure 1. Water balance of a high-density thickener in an iron ore concentrator plant

The main problems that operators face when handling this equipment in order to keep the production regime stable include the suspended solids in the recovered water and the density or percentage of solids of the thickener discharge outside the set targets. These problems are classified according to whether they are caused by thickener design errors, changes in ore properties, or mechanical and maintenance issues.
 whose main components are: feed lauder, drive, rakes, discharge pumps and flocculant preparation and dosing system. The main failures that can occur are:

Thickener design errors

In thickener design there are two specifications that will define the tank efficiency to process minerals that commonly have high variability properties and to adjust to the programmed processing tonnages during the life of the mining project. These design specifications are:

Thickener area

The area depends on the sedimentation rate of the mineral measured as unitary area m2/t/d or the specific feed rate t/h/m2 that is determined by laboratory or pilot test. These tests are carried out with different types of mineral, the granulometry and testing different dosages of flocculant. Additionally, the selection of an adequate safety factor that represents the variability of the mineral to be processed must be considered. The safety factor can vary between 1.15 and 1.30.

Drive torque

The rakes drive mechanism has to apply a sufficient force for the rakes to move the slurry in the thickener. The torque of the mechanism is proportional to the degree of viscosity of the thickened pulp measured as yield stress. The relationship between %solids and shear stress is exponential so that small changes in %solids generate a progressive increase in shear stress, and consequently the required torque. Figure 2 shows a rheology curve for iron ore tailings.

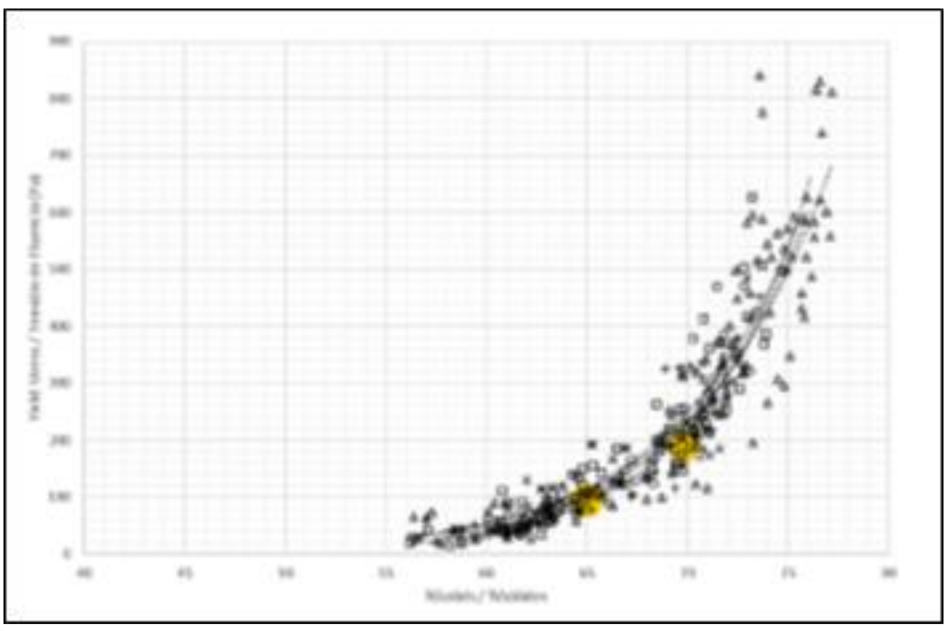

Figure 2. Yield stress vs % solids

Based on this data, suppliers apply safety factors that define the K torque factor that relates diameter to drive capacity:

$$K = \frac{\text{torque (lb-ft)}}{\text{diameter}^2 \text{ (ft)}}$$

In the event that mistakes of undersizing the area or torque have been made, the thickener operation will have capacity problems and will not meet the thickening target.

Common design errors:
Design errors appear after start-up when flow throughput or rheology variations exceed applied factors. Main design errors include:

1. Lack of capacity of the feeding launder
2. Less thickener area
3. Lower drive torque
4. Smaller feed-well diameter
5. Lower capacity pump discharge
6. Larger diameter of the discharge pipe (underflow). This produces mineral settling

Changes in ore properties
The ore fed to the thickener is essentially variable due to changes in upstream operations, for example mined sector, milling and concentration. The main changes that affect the thickener are:

Throughput variations
Due to changes in hardness and ore grade, the tailings and concentrate treatment rate change hourly. An automatic control system is necessary to keep the operation of the thickener stable, along with the use of online monitoring of the clear water and pulp phases inside the thickener. These layers can be monitored with systems such as SmartDiver and can be used to automatically control throughput variability.

Particle size variations (settling rate variation)

The sedimentation rate is strongly influenced by the particle size, so that the variations in the grinding stage are transferred to the thickening stage. When very fine ore is fed, the settling rate decreases which in turns can create issues such as increase in torque, clear water contamination and decrease of the % solids in the discharge

Coarse mineral
When the mineral has an increase in coarse fractions greater than 0.5 mm as a result of plugging of the hydrocyclones, sandblasting, problems are produced at the bottom of the thickener, increasing the torque effort of the dragging that can damage the mechanism.

Clay and ultrafines content variation (rheology change)
When the content of fine particles (clays or micas) increases more than 20% above their normal value due to their high specific surface, problems of excessive increase in rheology are generated e.g. viscosity and shear stress increase making thickening difficult. Mine planning is necessary to control the fines content under the specified values in the design.

Mechanical and maintenance issues
Sometimes problems that originate from failures in thickener components can occur. The most common are:

Mechanicals failure
Due to specific events of high torque as well as corrosion of the rake mechanism, the thickener gradually loses its torque capacity. In this scenario, Operators tend to run the system with a lower torque set point than that considered in the design to avoid a serious failure (breakage of the mechanism). This affects the thickening capacity by working with lower % solids (refer to figure 2). Overhaul and regular rake maintenance will be necessary to keep the mechanism working properly.

Another common issue is the wear of the discharge pump that loses its flow capacity. This occurs mainly in centrifugal pumps that are very sensitive to increased rheology, which not only affects the thickener stability, but also the discharge pressure of the pump.

Instrumentation and control issues

Errors in the choice of instrumentation technology and installation of instrumentation can result in inefficient thickener operations.

Another common issue reported is the inaccuracy of measurements mainly due to issues related to calibration not properly completed. These issues can be seen more frequently in density and flow meters. Inaccuracy in these measurements results in errors in the % solids calculated and operational decisions made.

Also common is the failure of external pulp level sensors becoming fouled with dust or mud which impact the measurements.

Problems also occur when the control strategy is misconceived. This results in unstable thickener phases (clear water, interface and thickened pulp bed). Refer to figure 3. As a rule of thumb, in conventional thickeners, the interface level should be 0.5 to 1.0 m below the surface and the thickened pulp bed (mud level) should be 2.0 to 3.0 m over the thickener bottom.

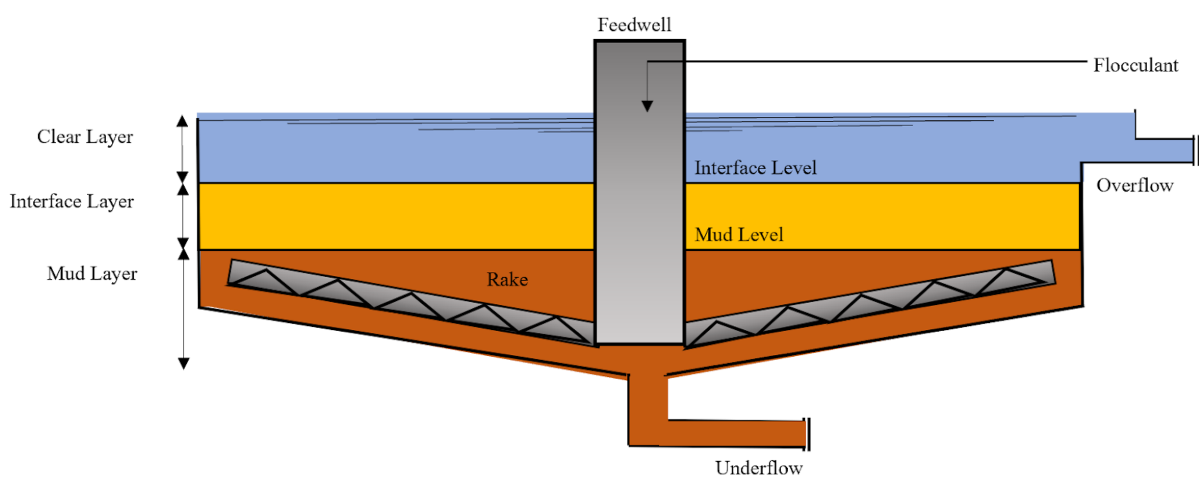

Figure 3. Thickener settling phases

An example of a suitable control loop is presented in figure 4.

1. Interface level with flocculant dosage.
   When the interface level starts raising, the suspended solids increase and contaminate the clear water. Then, the control loop increases the flocculant dose in turn lowering the interface layer to the predetermined setting.
2. Mud level with discharge pump speed
   When the mud level decreases there is less compression in the mud layer. This results in less % solids in the thickener discharge (underflow). Then, the control loop decreases the pump speed in order to increase the mud level consequently increasing the %solids in the discharge.

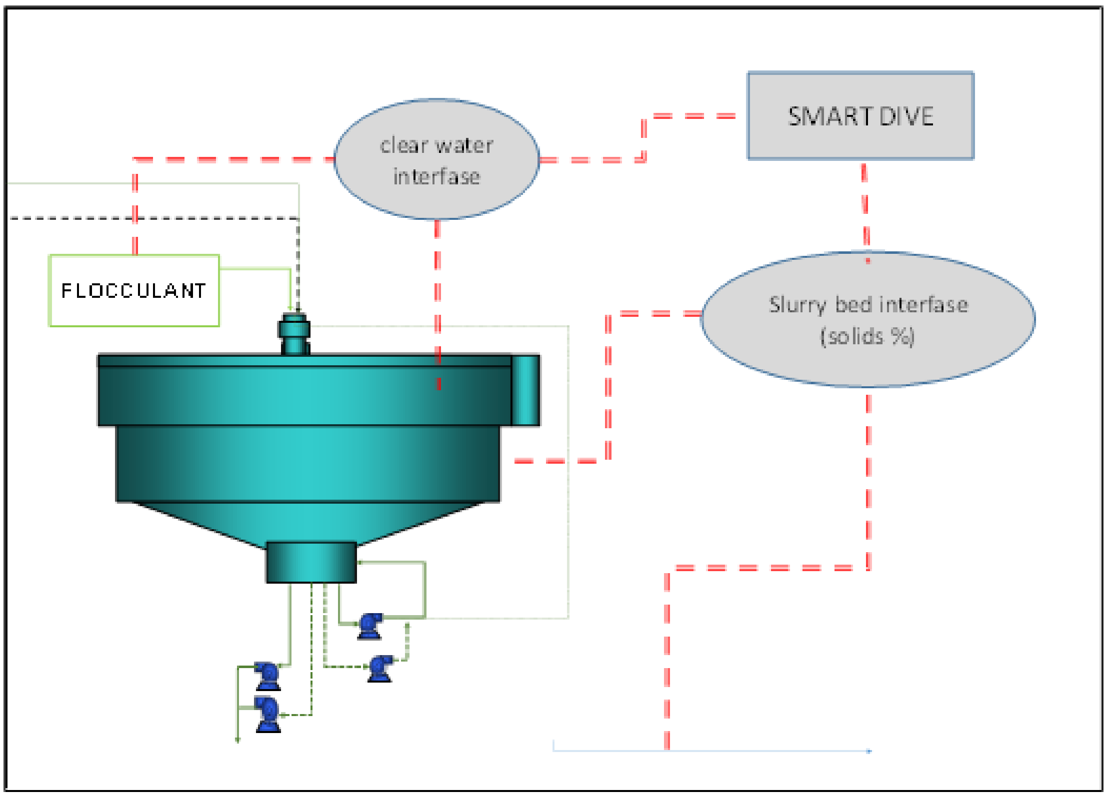

Table 1 summarizes the most common problems in thickeners, explaining the cause and the mitigating measures.

Typical thickening issues

	Issue	Cause	Mitigation
1.	Decreased production	Fine material	Mine/Grinding control
2.	Excess solids in the overflow	Fine material	Flocculant dosage
3.	Sliming or flare events	Fine material	Flocculant dosage/ layer control
4.	Excess water fed	High use in flotation	Flotation control
5.	Rake bogging	Fine material	Flocculant dosage
6.	Rake shaft breakages	Coarse material	Mine/Grinding control
7.	Excess Flocculant usage	Lost control	Automatic control
8.	Erratic underflow density	Lost control	Automatic control

Conclusions and recommendations

The main issues that mining plants face in thickener operations have their origin in three main sources: design, mineral variations and mechanical or instrumentation and control problems.

1.- The design stage is the most relevant aspect to determine the diameter (area) and the torque of the thickener. The main industry and manufacturers recommendations are: a) to carry out laboratory and pilot tests with representative samples along the mining plan; b) to perform sensitivity analysis versus mineral particle size distribution (granulometry): c) to apply safety factors according to the type of thickening technology to be used.

2.- The variation of mineral properties should be approached as an additional issue to geometallurgy. In the past, geometallurgy studies only focused on hardness-treatment and metallurgical recovery. Now, they include the sedimentation rate and rheology as control parameters for planning the production by limiting the content of problematic minerals such as clays or micas.

3.- The mechanical problems of the thickener drive mechanism should be controlled through a preventive maintenance program. Periodic reviews of corrosion damage, especially in plants using salty water, should be implemented. High torque safety limits should also be set. Sanding problems should be controlled upstream in the grinding stage with safety screens or avoiding the reverse grinding circuit, which is a source of coarse particles short-circuit coarse fed directly to the hydrocyclones.

4.- Regarding instrumentation and control problems, the periodic calibration of density meters, flow meters and level sensors is a mandatory task for the control loops to have high accuracy and availability.

5.- To improve the control strategies, consider technologies such as SmartDiver that deliver a greater number of continuous measurements (layers in the thickener) to implement more efficient control philosophies.