LARGE DIAMETER THICKENERS IN THE PHOSPHATE INDUSTRY

Abstract

Modern mineral processing plants handle large amounts of ore and produce large tailing streams . Plant performance can be optimized when the water is quickly recovered with a thickener. The caisson thickener was developed to overcome process and mechanical problems with the conventional traction and center column units. The caisson is a hollow center column that serves as a pump house. The rake arm structure is supported by a hydrostatic bearing which sits on top of the caisson. The caisson thickener with a hydrostatic bearing has operated for many years in several mineral processing applications.

James P. Bowersox
Senior Application Engineer
Minerals Processing

R. Lee Klaer
Resident Manager
Southern Industrial Sales

DORR-OLIVER

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Dorr-Oliver has participated for many years in the design and supply of large thickeners to handle tailings for the mineral processing industries. In fact, J.V.N. Dorr, one of the founders of Dorr-Oliver invented the continuous thickener in 1906 in the Black Hills in South Dakota. Dorr, who had developed the rake classifier two years earlier, felt that thickening could be made continuous and mechanical by providing a slowly moving rake mechanism for removing solids as they settled on the bottom of a tank. His own experience had shown him that area and not depth was the factor governing the capacity of slime thickening tanks. So Dorr reasoned that a shallow cylindrical tank of the same diameter should be just as effective as the deep cones in use at that time. Dorr's creative insight in solving mineral processing problems had undoubtedly been developed when he worked in the Menlo Park laboratories of Thomas Alva Edison.

Since the early part of the century when Dorr developed the continuous thickener, mineral processing plants have become much larger and the resulting tailing streams much bigger. For example, one plant where we recently installed two large tailings thickeners discharges 200,000 gpm of flow containing 40,000 tons per day of solids. Handling of these tailings streams can have a major impact on the design, location, and layout of any plant. Listed below are some of the things that must be considered in handling these tailings streams:

1) Water should be recovered as close to the plant as possible for re-use. It is very expensive to send the total tailings flow to a lagoon and then have to pump the water back to the plant.
2) Quick recovery of the water will minimize plant water temperature variations that can affect processing within the plant.
3) Sending a smaller stream to the tailings lagoon will also make more effective use of the tailings basin.
4) The thickened slurry will more easily carry the coarse solids and eliminate sanding problems in the tailings line.
5) Environmental constraints may force a plant to use a thickener due to lack of available space or to speed up land reclamation.

DEVELOPMENT OF THE LARGE TAILINGS THICKENERS

The first large tailings thickener was supplied to the copper industry in the American Southwest. It was a 200 foot diameter traction thickener. Here the thickener has one radial and three short arms and the rake structure is driven by traction wheels riding on a peripheral rail on top of the tank wall. The rake structure in the center is supported by a swivel bearing. At first

1) The conventional ball bearing support system was insufficient to meet the loading criteria for large thickeners.
2) The hydrostatic bearing could meet the higher load requirements and provide higher torque at the same time. Larger thickeners were now possible. Lifting devices had not proved to be trouble-free and the design of larger lifting devices seemed an unwise venture.
3) The caisson concept would totally eliminate the need for tunnels.
4) Underflow pumps could be placed at the bottom of the caisson. The long underflow suction line would be eliminated and the pump would always have a flooded suction.

The first of these units was installed to handle iron ore tailings in Minnesota in 1964. This unit operated trouble-free for many years, and when the mill expanded ten years later, two additional units were purchased.

THE CAISSON THICKENER

The caisson thickener was developed to take advantage of the dry well concept of withdrawing underflow into the center column. This concept required a center mechanism where it is possible to service or remove the underflow pumps.

The large diameter center column or caisson is sized to house the underflow pumps. Mechanisms have been built to service caissons between four meters and eight meters inside diameter. Several pumps are used to draw off the underflow. Two pumps, 180 degrees apart, three pumps, 120 degrees apart, or four pumps, 90 degrees apart, are used. This arrangement is due to the length of the discharge trench necessary around the large diameter caisson, and also due to the greater amount of solids to be handled. Multiple pumps, each with lines sized for their capacity, and stand-by pumps for handling maintenance requirements, are essential for proper operating flexibility.

Multiple pumps, important during peak operating conditions, are necessary to remove excess material and reduce high loads created by surges. They may be equally important during start-up, when it may be necessary to pump less material until the layer of solids with lighter slimes has settled near the center, or for recycling until the unit reaches equilibrium. The smaller lines, each sized for the capability of its respective pump, allow reduced quantities of flow to be pumped and keep line velocities high enough to prevent heavier solids from settling in the vertical lines exiting the caisson. They also minimize the problem encountered in evacuating a large quantity of solids and prevent short-circuiting of the underflow pump draw-off to the more dilute settled slurry or clear liquid. If geological conditions permit, the caisson diameter can be expanded below the level of the discharge trench to create a larger area to house the pumps. This configuration provides added head on the suction side of the pump. The area is obtained without added structural cage costs that would be necessary if the

The rake arm which helps to transport settled solids to the center of the machine is attached to the center cage which surrounds the caisson. The cage is attached to the internal gear runner through a drive lug and pin arrangement.

The entire structure is then supported on the oil film and rotated by a conventional drive arrangement. Two, three, or four of these pinion gear motor configurations are used depending on the torque requirements for the thickener.

LARGE THICKENER ECONOMICS

Substantial savings can be achieved in plant design whenever one large thickener can be designed to perform the function of two smaller units. The savings come mainly from the costs associated with tank construction. For example, only one tank wall need be constructed. Here there is almost a 30% reduction in excavation work for the wall and in materials to construct the wall and overflow launder. The length of feed lines and underflow lines is also reduced by 30%, although the size of the lines will increase somewhat.

In addition, there are smaller savings for one larger mechanism and a single center pier support. These savings are found in initial cost, installation, operation and maintenance.

An additional large cost saving can result from the caisson with the elimination of a tunnel, especially if the tunnel must go under the diameter of the tank. The excavation of the trench, construction of the tunnel, and backfilling of the trench are no longer necessary.

These large thickeners are normally gravity-fed by a launder which hangs below the truss. One end of the truss is supported on the caisson and the other end on a concrete pier at the thickener periphery. The launder truss terminates into a feedwell which surrounds the caisson. The underflow lines from the pumps at the bottom of the caisson are also carried on the truss, usually on the top. Since both the feed and underflow lines are now accessible, they are easily maintained and any plugs can be quickly eliminated. Although the truss is somewhat expensive, the cost of burying the lines beneath the tank floor is eliminated and the lines are now accessible for maintenance and much easier to keep in operation.

The truss also provides access to the center mechanism and underflow pumps for routine maintenance procedures. The truss is equipped with a monorail crane so that underflow pumps can be removed for major repairs. Pumps can be removed from the caisson by lifting them through the opening in the center mechanism. Once at the top of the caisson, the pump can be transported across the bridge with the same crane, loaded onto a truck and taken to the repair shop.

SUMMARY

Since the start-up of the first caisson thickener with a hydrostatic bearing in 1964, Dorr-Oliver has sold eighteen additional units. All but one are caissons. Of the nineteen, one is being erected, the others are in operation. We feel that the success of these units strongly demonstrates the benefits of the caisson hydrostatic bearing concept.