TESTING A NEW METHOD FOR THE TREATMENT OF SLIMES IN THE PHOSPHATE INDUSTRY

By:

Dr. Steven W. CLARK
Chief Metallurgist, GARDINIER, Inc.
Fort Meade, Florida

Dr. Jacques A. PICHON
Chief Engineer, ALSTHOM ATLANTIC, Inc.
New Orleans, Louisiana

1. INTRODUCTION

Ore beneficiation plants, especially phosphate plants, usually discharge large volumes of water containing variable amounts of clay and other unused material. In mountainous areas, these slimes may often be dealt with conveniently by building a dike across a valley and discharging the slimes behind the dike. The disposal area thus created can also act as a settling pond whose size does away with the need for flocculent.

In flat areas like Florida, dikes have to be built around the entire circumference of the disposal area. The cost of these dikes, the danger of dike failure in the long term and the conversion of large areas into useless marshland are three major incentives to look for schemes with less pronounced drawbacks.

Similar problems are found in other countries where lack of space for slimes disposal or a general lack of water has called for new methods of washwater clarification, sludge compaction and final or temporary disposal.

This paper describes the ALSTHOM ATLANTIC slimes processing and the disposal schemes engineered to date.

2. DESCRIPTION OF THE PROCESS

The complete process from raw slime to disposal comprises four stages :

* Water clarification and sludge generation.
* Sludge compaction with superflocculation.
* Semi-dry slimes disposal.
* Reclamation.

The four stages are described below, in order.

2.1. Water Clarification by the Clariflux process

The raw water or slime is clarified in a Neyrtec " CLARIFLUX " clarifier, which acts in almost the same way as a conventional thickener. The only major difference between the two is that the CLARIFLUX comprises two stages: a sludge-blanket clarifying stage and a sludge concentration stage. This division into two stages makes each stage more efficient and generally leads to a reduction in the consumption of flocculant or in the surface area needed for settling.

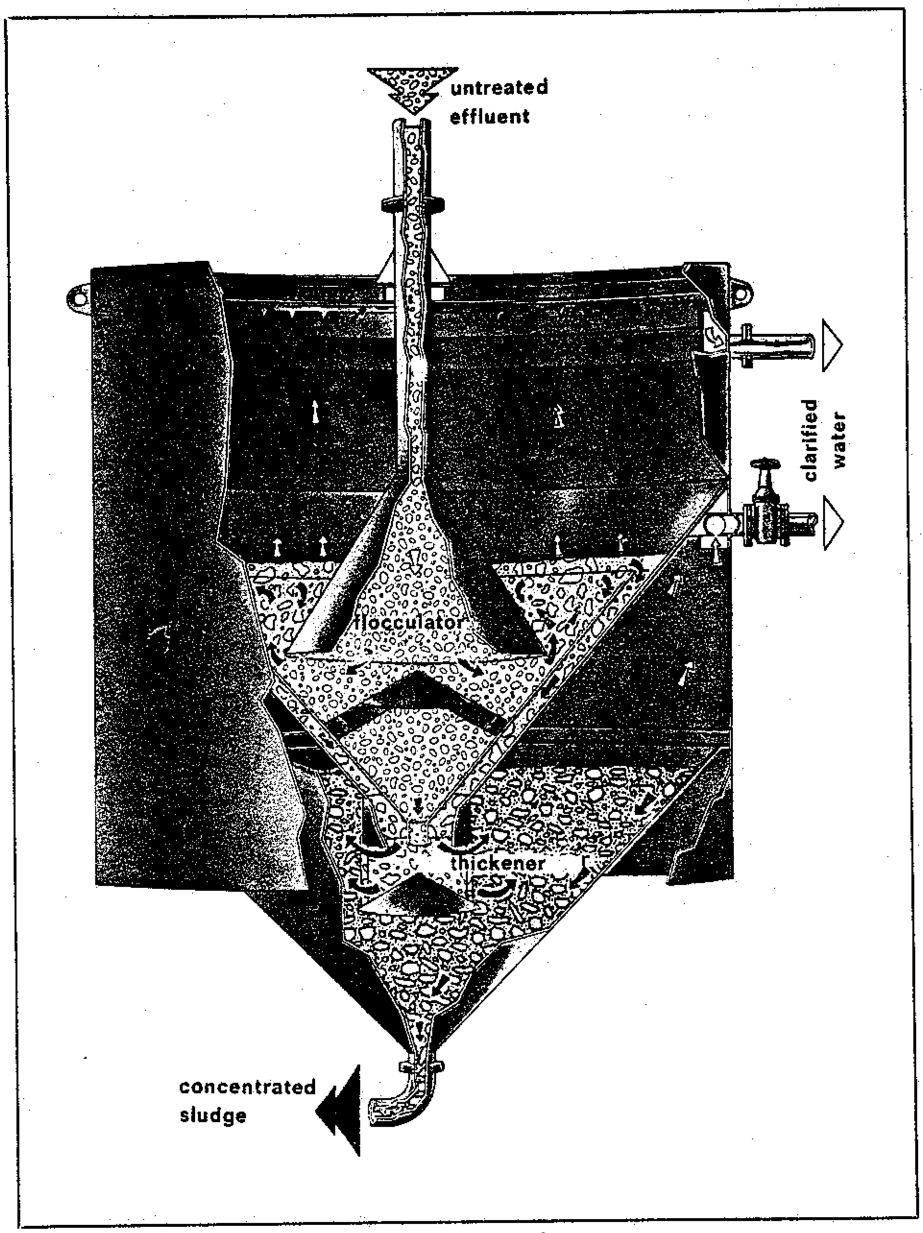
Both of these advantages apply to the Florida slimes.

The CLARIFLUX process is based on the acceleration of solid particle flocculation through a sludge blanket which is regulated by an entirely new system.

The CLARIFLUX unit, a fully static design, comprises a flocculator, a clarifier and a thickener.

The flocculator initiates floc formation by flocculant action on the solid particles. It feeds the clarifier above it through a circular slit at the bottom of the clarifier. Coarse solid particles and large flocs are extracted and fed to the thickener through a free orifice at the bottom of the flocculator.

The clarifier is the first stage of the CLARIFLUX unit. It consists of a cylindrical upper portion and a lower portion in the shape of a conical torus extending down to a sludge blanket in the bottom of the unit. Sediment-laden water from the flocculator passes through a circular slit at the bottom of the clarifier into the sludge blanket produced by the flocs in this water.


untreated
effluent
clarified
water
flocculator
thickener
concentrated
sludge

As the flow slows down, the fine flocs from the flocculator agglutinate with the large flocs circulating in the clarifier sludge blanket, thus increasing floc size and bulk density and thereby quite substantially accelerating the mean water velocity through the clarifier.

The thickener is the second stage of the CLARIFLUX unit. It is a funnel-shaped device which is supplied in its central portion with pre-concentrated sludge from the flocculator and delivers concentrated sludge at a set rate through a bottom outlet. The clarified water discharges through calibrated orifices in an annulus at the top of the thickener.

2.2. Sludge compaction with superflocculation

The main goal of the treatment is to send the concentrated slimes extracted from the CLARIFLUX back to the mining cuts.

Just before the disposal, another treatment by adding flocculant is done : it is the superflocculation. The superflocculation process based on a controlled use of flocculant, provokes a quick dewatering of the disposed slimes. In one night, the concentration of slimes reaches 20 %. After one week, it is approximately 30 %.

2.3. Semi-dry disposal of slimes

Unlike all other known processes, the ALSTHOM ATLANTIC process does not consist of placing the sludge in ponds in which they are maintained under water for final settling. On the contrary, the ALSTHOM ATLANTIC process takes advantage of the viscous flow properties of the slimes, which are allowed to flow on inclined surfaces in the mining cuts with a slope of approximately 5 to 10 percent. The low flow velocity keeps the floc moving slowly and this frees the trapped water mechanically. The water, freed, flows at the top of the "alluvial" cone and precedes the slower viscous flow. This allows the water to be removed by filtration, either into the ground or through a filtering dike.

If the thin layers of slime as initially placed in the disposal area are not immediately covered over by further layers, additional dessication occurs due to wind and the heat of the sun. The ALSTHOM ATLANTIC scheme therefore provides for alternating slime disposal to allow the sun and the wind to act.

The final material can in fact no longer be called a viscous sludge. It appears rather as a series of "chunks" of material separated by large cracks created by the sun and wind. The chunks cannot however be compared to blocks of ore of similar size, but the dewatered material no longer has liquid or plastic properties.

2.4. Reclamation

After filling a cut, the "drying" period is short. During this time, nothing is done on the cut.

At the end of the drying period, the overburden is spread over the slimes. Light vehicles can then operate on the surface and the land is usable for agricultural purposes.

3. DISPOSAL OF FLORIDA PHOSPHATIC CLAY SLIMES BY THICKENING

3.1 Review of the Problem

The Florida Phosphate Industry has been plagued with the disposal of clay slimes washed from phosphate rock because it has become increasingly difficult to find aesthetically and environmentally acceptable disposal methods. Phosphatic clay slimes are now generally impounded behind high dams where they consolidate to 30% to 40% solids after many years.

Dam failures in years gone by resulted in inundation of farmers' crops and silting of streams, although no long-term damage was done. The potential for dam failure was largely eliminated by stringent construction codes, but the mere presence of the high dams has become aesthetically objectionable.

The Florida Phosphate Council initiated a series of slimes disposal seminars and research activities in the late 1970's to generate industry-wide action to find alternatives other than impoundment behind high dams to dispose of the slimes. Several methods of slimes disposal were tested full-scale or on semi-works levels:

1. Sand-spraying.
2. Flocculation and thickening.
3. Dredge-mixing of sand and slimes.

The goal of all these methods was to mix sand and slimes to obtain a soil which would allow mined-out areas to be reclaimed as useful land. One company has used sand spraying full-scale for several years but has had difficulty with the logistics of having sand and clay at the right place under the right conditions at the right time. Dredge mixing of sand and slimes is being tested full scale by two groups who expect to produce land suitable for grazing of cattle.

3.2 Gardinier, Inc., Test Installations for Slimes Thickening

Flocculation and thickening has the advantage of treating and disposing of the slimes as they are generated, immediately returning clarified water. Gardinier, Inc., has tested pilot-scale thickeners from five companies. Of these, the sludge-bed thickeners are the only units which could be regarded as successful for thickening of phosphatic clay slimes. In a sludge-bed thickener, the feed is introduced into the bed of thickened material formed in the thickener bottom, setting up a blanket of solids through which water is filtered and thereby clarified.

A five meter (16.2 ft.) diameter Clariflux Thickener was installed at the Fort Meade Mine of Gardinier, Inc., to generate enough thickened slimes to determine if the slimes could be dewatered sufficiently to return them to mining cuts, hence being able to dispose of slimes without building high dams.

Goals of the Clariflux Thickener Study:

(1) Determine if slimes thickening would allow slimes disposal without building of high dams;

(2) Thicken the slimes as they come from the desliming section, coping with all process variables;

(3) Determine a control scheme for automatic proportioning of the correct flocculant dosage for slimes thickening;

(4) Determine the pumpability of thickened slimes and the pumpability of sand-slimes mixtures;

(5) Determine the throughput and thickening capabilities of the Clariflux Thickener;

(6) Determine the economics of slimes thickening.

3.3 Operation of the Clariflux Thickener

The slimes to the pilot-scale thickener come from the desliming section at 1% to 6% solids by gravity flow, passing a Doppler effect flowmeter and a nuclear density gauge. A multiplier calculates mass flow of slimes from the flow and density readings. Flocculant addition is automatically proportioned to the mass flow of slimes entering the thickener. Seven hundred (700) to one thousand (1,000) GPM of fresh slimes enters the system where it is mixed with flocculant diluted with 300 to 800 GPM of thickener overflow. Ordinarily, one-third of the flocculant is added to the slimes at the entrance of a mix tank and the remaining two-thirds is added as the slimes enter the thickener. Slimes are thickened to 10% to 15% solids depending on slimes type and flocculant dosage, then pumped to the disposal area. Flocculants are available commercially as dry powders, liquids (or emulsions) and gels. Ability to use all three forms has been installed. Flocculants from five different manufacturers have been tested full-scale in extended runs. Liquids (emulsions) are easiest to handle, dry powders are most widely available, gels have shown some of the best performance.

3.4 Initial Results of Slimes Thickening

After operating the thickener for nine weeks, the first mining cut 1,000 ft. long by 125 ft. wide was filled with slimes at an average 13.5% solids. The pond was then drained for eight weeks. The percent solids of the slimes increased to an average 22.5% solids in the first two weeks, but did not increase beyond this level even though water flowed continuously out the drain. It was found that ground water was draining into the pond, preventing the slimes from drying.

A sand-slimes mixture was used to fill a second mined-out cut of approximately the same size. After the cut was filled with slimes and allowed to dewater, it was discovered that the sand was deposited in a large, gently sloping delta extending out 300 ft. from the fill point. This delta could be walked upon and was 60% to 75% solids. However, the solids contained 80% to 90% of +150 mesh sand, most of the slimes having flowed to the far end of the cut. There was a very distinct boundary at the edge of the sand delta, beyond which the percentage of sand in the slimes dropped to only 10% in a few feet.

At this time we were somewhat discouraged with the results of the project:

(1) The thickened slimes were dewatering very slowly, if at all, beyond 22.5% solids.

(2) The sand and slimes of the sand-slimes mixture had obviously separated.

4. The Superflocculation Process for Slimes Dewatering

Small-scale tests by Alsthom Atlantic scientists showed that secondary addition of flocculant to thickened slimes caused rapid further dewatering. Both continuous and batch tests gave encouraging results. Equipment and procedures were organized to accomplish secondary flocculation of the full discharge of the pilot-scale Clariflux Thickener. Dubed "superflocculation", the process formed a sludge which dewatered rapidly after a series of adjustments in equipment type and equipment arrangement were made to obtain thorough mixing of flocculant and slimes and to prevent destruction of large flocs once they were formed. Clear water flowed rapidly away from the large flocs into a collection pool at the end of a short mining cut from which the water was recycled for dilution of the flocculant used in superflocculation. The recycle water contained appreciable amounts of flocculant and reduced the flocculant requirements of superflocculation.

4.1 Results of Superflocculation of Thickened Slimes

The thickened slimes immediately dewater from 10% to 15% slimes solids in the thickener underflow to 18% to 20% slimes solids after superflocculation, and further to 20% to 22% slimes solids after draining in the disposal area overnight. The sludge forms a stable slope of 5° to 10° in the deposition area, allowing complete drainage of rainwater or of water released during superflocculation.

After dewatering for one week the sludge reached 25% to 30% slimes solids. Longer drainage times have not been possible because ongoing experimentation does not allow the main disposal area to remain inactive.

4.2 Advantages of Superflocculation

The rapid dewatering obtained by thickening and superflocculation makes it possible to greatly decrease the volume required for containment of slimes while dewatering. Test trenches and pits of superflocculated slimes dewater in a few weeks to 40% to 50% slimes solids. However, it has not yet been demonstrated in a full-scale operation that sufficient dewatering can be obtained in a reasonable length of time to enable the slimes to be completely returned to the mined-out cuts without building any kind of dams. A thickener installation to handle the complete slimes load from the Gardinier, Inc., Fort Meade Mine beneficiation plant is being engineered while test work continues. The rate at which the material dewaters and its consistency gives cause of great optimism that the material can be disposed of in the mined-out areas to quickly form useable soil.