

Chapter 13

DEISTER FLOTAIRE COLUMN FLOTATION CELL-PLANT EXPERIENCE

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ABSTRACT

Coal flotation applications utilizing column flotation have been shown to improve grade and recovery when compared with traditional mechanical cell flotation. Deister Flotaire Column Flotation Machines have been installed in pilot and commercial coal cleaning applications. Comparative data covering prior and current flotation is presented. In addition, special characteristics covering the Deister air generation system are presented.

INTRODUCTION

Over the last decade, column flotation has become a widely recognized and accepted method of flotation of metallic minerals, coal and industrial minerals. Commercial and pilot column flotation applications have shown significant improvements in grade and recovery of copper, molybdenum, iron, lead, zinc, gold, coarse and ultrafine coal, lithium, magnesite, talc, phosphate and other minerals. These installations include uses in rougher, scavenger and cleaner operations.

In this paper, a brief history of the Deister Flotaire and a description of the Flotaire Column Flotation Cell features are given, along with details of several commercial applications of the Flotaire. Also described herein are improved methods of bubble generation and distribution and the development of a new computerized froth overflow rate control apparatus, which are just some of the latest advances in column flotation technology developed by The Deister Concentrator Co., Inc.

BACKGROUND HISTORY

The Deister Flotaire Column Flotation Cell was originally designed and developed to process coarse and hard-to-float phosphate minerals, and was first commercialized in 1977. Shortly after its introduction, 15 full-size 2.4 m (8.0 ft.) dia. and numerous smaller diameter laboratory and pilot units were installed in the phosphate industry. These original Flotaire Cells utilized

aspiration techniques, mixing pressurized, surface-tension lowered water (typically 30-60 dynes/cm²) with air to generate micron-sized (less than 0.1 mm) air bubbles. This successful bubble generation technique required 40 L/min (10 GPM) of hydraulic water at 40 PSIG for each SCFM of air. The air bubble/water discharge from each aspirator used was introduced directly into the bottom of the column. In a 2.4 m (8.0 ft.) dia. unit, typically 100-150 SCFM was required. Because phosphate flotation requires high solids conditioning with fatty acid and collectors, the high percentage of hydraulic water used for air aspiration assisted in internal pulp dilution that gave the proper pulp density for flotation.

The success of the Flotaire in the phosphate flotation area led to research and development work in coal and metallic mineral flotation. In these applications, the low percent solids feeds available dictated a complete redesign of the aeration methods employed with the Flotaire. These newer Flotaires were known as second generation Flotaires.

Second generation Flotaire Column Flotation Cells employ two aeration methods for the generation of micron-sized bubbles (less than 0.05 mm dia.) Externally-mounted compressed air aspirators utilized surface tension-lowered water aspirated into a compressed air stream to generate 50-70% of the total micron-sized bubble requirements within the column. Critical to the success of this aeration method was the bubble distribution system utilizing a multi-outlet manifold located below the bottom of the pulp zone in the column. The second aeration method utilized porous tube micro-diffusers. These used compressed air only and provided 30-50% of the total air in the column, but typically in bubble sizes ranging from 0.1 mm - 1 mm. The micro diffusers were originally located 0.6 - 0.9 m (2-3 ft.) inside and above the bottom of the column pulp zone.

One significant feature of the current Flotaire design that came about during the development of this second aeration method was the introduction of micron-sized bubbles through microdiffusers at

an intermediate level within the column. This level is typically identified as the point halfway between the lowest aeration level and the overflow level of the column. This feature permits the upper recovery zone of the Flotaire to utilize 100% of the total air and quickly float the easy-to-float material in the feed. Below this intermediate aeration level, the lower air hold-up volume permits longer retention time of the harder-to-float particles in the presence of the micron-sized bubbles at a reduced downward velocity.

Another development that was utilized in second generation Flotaires to further improve the concentrate grade was a froth washing system. Froth washing originally started with non-metallic flotation applications.

An important feature of column flotation is the ability to achieve a deep froth layer, typically 0.3 - 0.9m (1-3 ft.), which permits use of a froth wash system. In the froth wash arrangement, a volume of water is evenly distributed within the froth below the froth discharge level. The volume of froth wash water used is determined by the liquid volume in the froth overflow. Generally, it is desirable to use a volume of froth wash water which exceeds the rising froth water volume to obtain a counter-current flow.

Froth washing enhances the grade of the final product obtained. Some of the gangue particles which enter into the column with the feed water become entrapped with the floatable minerals or are suspended as slime in the water between the mineral-laden bubbles. Froth washing causes the gangue particles to be flushed back into the pulp and eventually report to the tailings.

The height range of second generation Flotaires is 7.3 m - 15.2 m (24-50 ft.) with the column volumes as large as 62 cubic meters (2200 cubic feet) current in operation. Pilot testing on second generation Flotaires began in 1985 and since then, over 30 commercial size 2.4m (8.0 ft.) dia. Flotaires have been installed. Almost three times that number Flotaires in smaller diameters have been installed in laboratory and pilot plant applications.

The pneumatic pulp level control system originally developed for the Flotaire is still used today because of its accurate ability to maintain the column pulp level within 25-40 mm (1 - 1-1/2") of the set point, even with variations in the column feed rate. Only major variations in the column pulp density can cause greater variations in the column pulp level, but which are typically operator set-point controlled. An alternative pneumatic/electronic level control system with 4-20 mA input/output is also available, which provides remote sensing and control based upon the same operating principles as the pneumatic level system.

CURRENT DEISTER FLOTAIRE FEATURES

One of the most important areas recognized during the development of the second generation Flotaires was the need to reduce column down time required for the occasional clean out of the lower aeration distribution system and the replacement of microdiffusers. Although the typical microdiffuser life was 3-6 months, depending upon the scaling conditions within the column, it was necessary to completely drain the column to remove the microdiffusers through flanged outlets.

Research and development by Deister has led to the current, patented Deister Air Generator System that is used on all current, or third generation, Flotaires shown in Figure 1. The Deister Air Generator provides better control of the bubble size and distribution to the Flotaire, improving flotation grade and recovery, but is installed completely external to the column. The generator system requires only 4-6 L/min. (1-1.5 GPM) of water for 10 SCFM of air, both at 60 PSIG. This reduced water requirement allows efficient processing of very dilute feeds, and reduces the impact of increased tailings flows to pumps and thickeners.

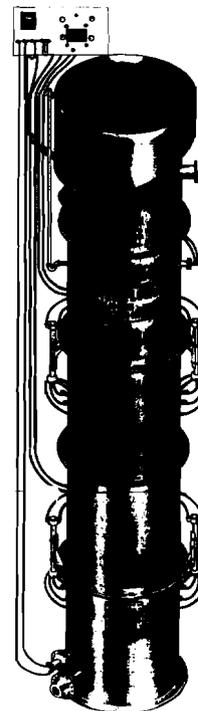


FIGURE 1. Deister Flotaire Column Flotation Cell

The Deister Air Generator was recently compared with older methods of bubble generation systems developed by Deister along with bubble generating systems using fine injector tips and filter sock type spargers. Results of the testing are shown on Figure 2. The test work was conducted at a major U.S. copper concentrator in their moly flotation circuit. The bubble size control capability and the bubble distribution system

contributed to the improved performance in side by side comparison.

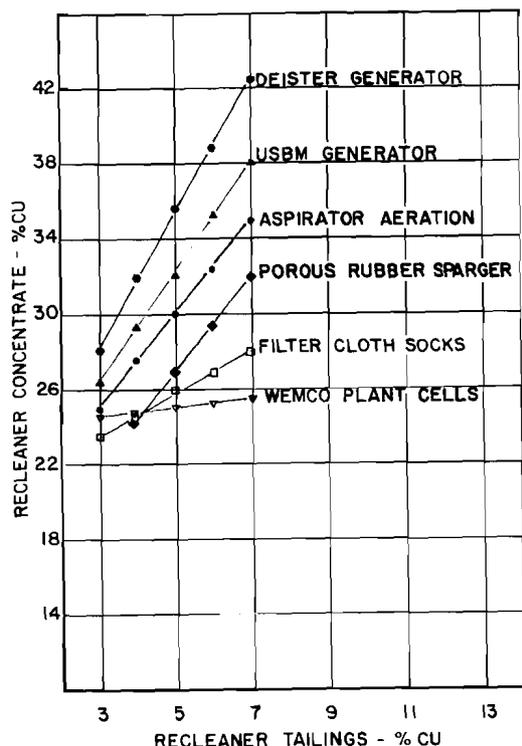


FIGURE 2. Performance Comparison of Various Column Flotation Aeration Systems

The Deister Air Generator is designed to accommodate a specific air and water flow volume. Inside the generator, compressed air flows radially inward through a micro-porous tube where it comes in contact with a high velocity flow of water. Located coaxially within the porous member is an inner tapered member. This tapered inner member causes the pressurized water to flow at a high velocity along the inner porous tube surface, shearing off the air bubbles as they emerge from the porous tube. The bubbles become entrained in the flowing stream as micron-sized bubbles. As the volume of the flowing air/water stream increases, the tapered rod increases the volumetric area inside the generator, maintaining the high velocity of the flowing air/water stream and the shearing action taking place. The flowing air/water stream is then divided at the outlet of the generator into a plurality of flow streams without a decrease in fluid velocity.

The discharge tubes on the generator report directly to the inside of the column with no expansion or contraction points that could cause air bubble coalescence. These flexible tubes extend from the generator through compression fittings and pass directly through the cell wall. A cut-a-way view of the generator and distribution system is shown in figure 3.

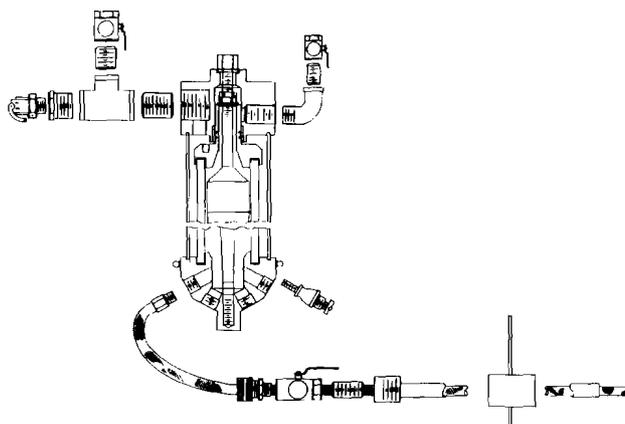


FIGURE 3. Deister Air Generator System Diagram

The uniform bubble distribution throughout the flotation column cross section is obtained by allowing the ends of the flexible tubes to oscillate by propulsion from the air/water discharge pressure.

All maintenance to the generator and distribution system can be performed on a 6-month preventative maintenance basis without disrupting cell operation.

The current froth wash system used on the third generation Flotaires is of a radial pattern that provides maximum column surface area coverage. Incorporated with the froth wash arrangement is a froth crowder, which was another earlier development on the second generation Flotaires. The froth is forced outward into the launder radially by the froth crowder and by the rising bubbles in the froth underneath. The froth crowder also eliminates the dead zone typically located in the central part of the froth surface.

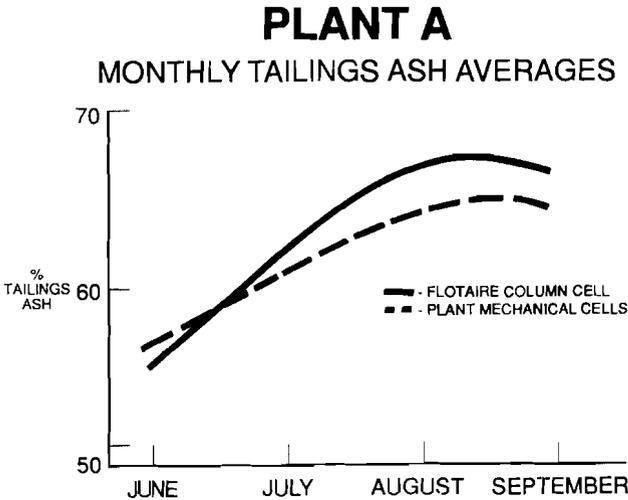
Column Flotation Cells are best distinguished from each other by (1) their method of pulp level control and column operational control features and (2) by their air bubble generation and distribution method. Extensive research has identified many variables which can effect column flotation results to one degree or another, including froth removal rate, downward pulp bias flow, solids retention time and pulp level, or froth depth, control. The most important column cell control is that which maintains an optimum economic compromise between product grade and recovery.

One recent control installed and tested on a Flotaire Column Flotation Cell utilized a 50 KHz ultrasonic transducer to measure the froth grade and product recovery. Testing of the froth product through an on-stream ash analyzer provided data to a microprocessor which in turn controlled a portion of the total air flow into the column. By automatically increasing or decreasing the air flow, an optimum froth removal rate was maintained for control of product ash. This system operated in conjunction with the pneumatic pulp level control system used on the Flotaire, which maintained the preset pulp/froth interface level in the column. This system is most effective in plants with multi-coal seam feeds.

APPLICATIONS AND PERFORMANCE

PLANT A

The first commercial size 2.4 m (8.0 ft.) dia. Deister Flotaire Column Flotation Cell built for coarse coal flotation was commissioned in 1986 in a coal preparation plant in Pennsylvania. This unit was installed to improve the recovery of -0.6 mm (-28 mesh) coal which was being lost to the tailings in the plant's existing mechanical flotation cells.



FLOTAIRE SIZE:2.4M DIA. X 5.2M TALL
 FLOTAIRE MODEL NO.:FL80-600
 FEED SIZE:0.6mm X 0.2mm
 FEED ASH AVERAGE:13.5 %
 COAL SEAM(S):LOWER KITTANNING

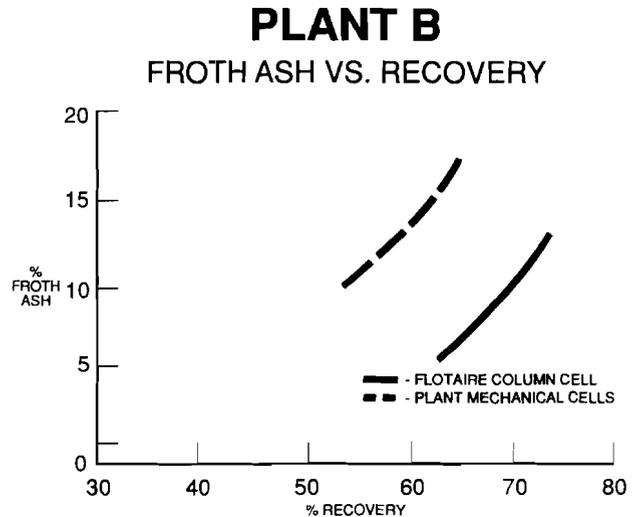
FIGURE 4. Plant A Performance

After the Flotaire installation, the plant circuit was changed so that a majority of -0.6 mm x 0.2 mm (-28 mesh x 65 mesh) material from Sieve bend and centrifuge underflows reports to the

Flotaire. The mechanical flotation cells continue to process the -65 mesh classifying cyclone underflow. With this scheme, the client has realized an average 5.5% increase in recovery, which translates to 10.4 TPH of additional clean coal output. Improvement in mechanical cell performance was also obtained through the increased retention time provided after the Flotaire installation.

PLANT B

In pilot testing, the Flotaire proved it's ability to increase recovery and decrease the froth ash currently being obtained with plant mechanical flotation cells. The fine coal feed contains a large percentage of clay, that tends to be of a coarse nature. Froth washing was used on the pilot Flotaire.



FLOTAIRE SIZE:PILOT FLOTAIRE
 FEED SIZE:0.6mm X 0
 FEED ASH AVERAGE:34.6 %
 COAL SEAM(S):LOWER KITTANNING,
 MIDDLE KITTANNING

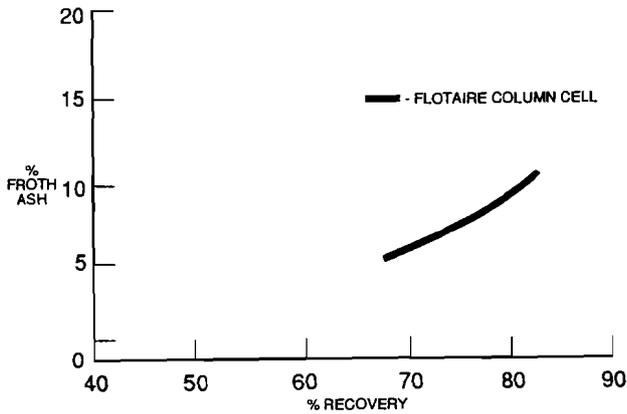
FIGURE 5. Plant B Performance

PLANT C

Flotation of coal in the Illinois No. 6 Coal Seam has proven difficult in mechanical flotation cells due to the high fine clay content and high feed ash. Pilot testing on the Flotaire with froth washing proved it's capability to produce a low ash clean coal product. No mechanical flotation is being used at this plant because earlier mechanical cell lab tests showed poor recovery and product quality.

PLANT C

FROTH ASH VS. RECOVERY

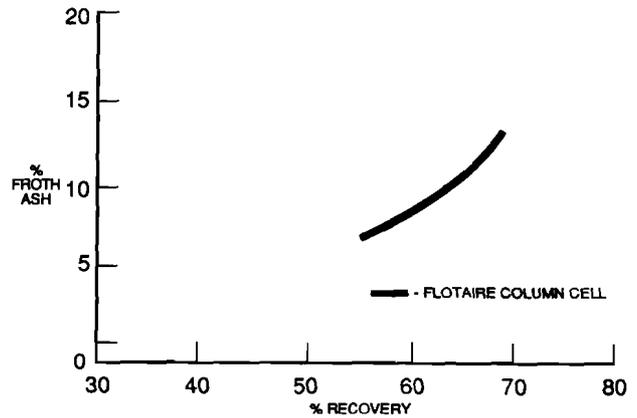


FLOTAIRE SIZE:PILOT FLOTAIRE
 FEED SIZE:0.6mm X 0
 FEED ASH AVERAGE:53.0 %
 COAL SEAM(S):NO. 6 (ILLINOIS)

FIGURE 6. Plant C Performance

PLANT D

FROTH ASH VS. RECOVERY



FLOTAIRE SIZE:PILOT FLOTAIRE
 FEED SIZE:0.6mm X 0
 FEED ASH AVERAGE:55.4 %
 COAL SEAM(S):HAZARD NO. 4

FIGURE 7. Plant D Performance

PLANT D

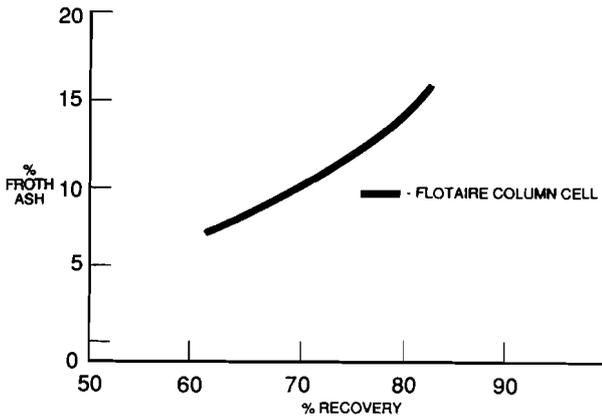
Here again, the pilot scale Flotaire proved it's ability to produce a saleable clean coal product from the Hazard No. 4 Seam that also has a very high fine clay content. Presently, no flotation is used at the plant, and the -0.6 mm (-28 mesh) product is discarded. Earlier mechanical flotation lab tests showed poor recovery and product quality.

PLANT E

Installation of a 0.8 m (2.5 ft.) dia. Flotaire Cell at this plant was the best way to prove it's performance on the various coal seams the plant processed. Previous mechanical flotation cell test work at the plant showed difficulty in obtaining acceptable recovery and product quality, and thus no flotation equipment was installed. The Flotaire had proven it's capability to produce a low ash clean coal product from the high ash feed. Clays in the plant feed tend to be coarse in nature. Froth washing was utilized on this Flotaire column application.

PLANT E

FROTH ASH VS. RECOVERY

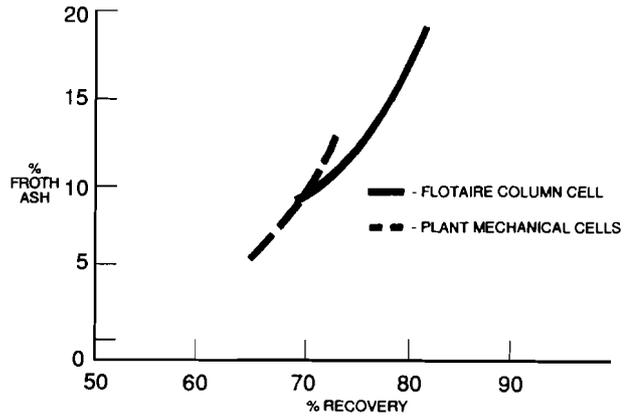


FLOTAIRE SIZE:.....0.8M DIA. x 7.6M TALL
 FLOTAIRE MODEL NO.:FL25-110
 FEED SIZE:0.6mm x 0
 FEED ASH AVERAGE:42.2 % ASH
 COAL SEAM(S):WARFIELD, UPPER ALMA,
 ALMA, CEDAR GROVE

FIGURE 8. Plant E Performance

PLANT F

FROTH ASH VS. RECOVERY



FLOTAIRE SIZE:.....0.8M DIA. X 7.6M TALL
 FLOTAIRE MODEL NO.:FL25-110
 FEED SIZE:0.6mm X 0
 FEED ASH AVERAGE:51.2% ASH
 COAL SEAM(S):SPLASH DAM, HAGY, EAGLE

FIGURE 9. Plant F Performance

PLANT F

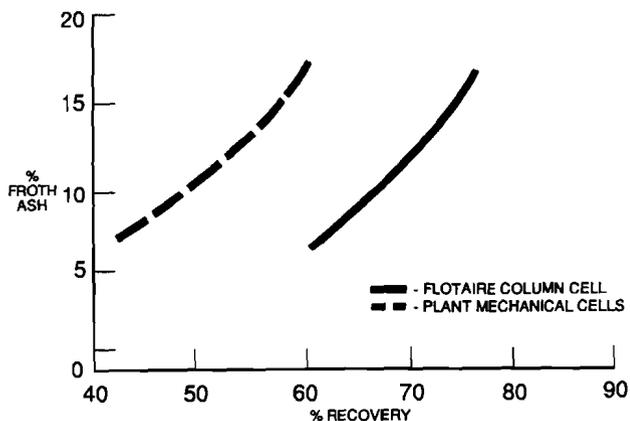
Testing of the 0.8 m (2.5 ft.) dia. Flotaire at this plant was conducted on feed similar to Plant E, which tended to be high ash and with a high coarse clay content. The Flotaire's ability to produce a deep froth and use of the froth washing system played a significant part in producing a low ash clean coal product.

PLANT G

The second 2.4 m (8.0 ft.) dia. Flotaire Column Flotation Cell in a coal application was installed to process -0.15 mm x 0 (-100 mesh x 0) coal feed. Both Flotaire and plant mechanical flotation cells are processing the same feed. This plant processes coal from various coal seams as well as various mines, making process conditions difficult to control. Many of the coal seams processed are high ash and contain a high content of fine clay. The Flotaire furnished with the automatic level control system aids in maintaining a continuous product overflow for optimum performance. Froth washing used on this Flotaire assures a quality clean coal product.

PLANT G

FROTH ASH VS. RECOVERY

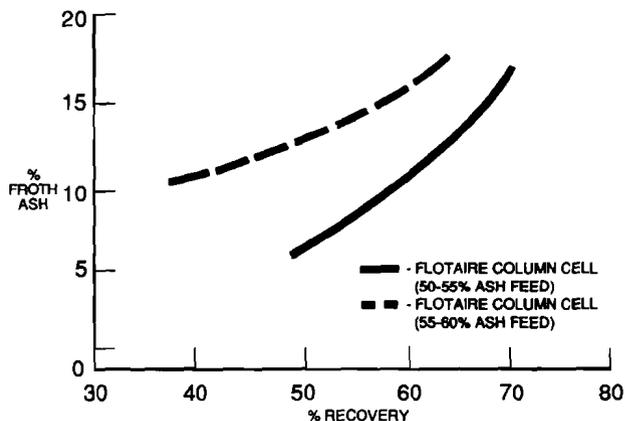


FLOTAIRE SIZE:.....2.4M DIA. X 7.6M TALL
 FLOTAIRE MODEL NO.:FL80-1000
 FEED SIZE:0.15mm X 0
 FEED ASH RANGE:31 - 42 %
 COAL SEAM(S):SPLASH DAM, CLINTWOOD,
 HAGY

FIGURE 10. Plant G Performance

PLANT H

FROTH ASH VS. RECOVERY



FLOTAIRE SIZE:0.8M DIA. X 7.6M TALL
 FLOTAIRE MODEL NO.:FL25-160
 FEED SIZE:0.15mm X 0
 FEED ASH AVERAGE:50 - 55 %, 55 - 60 %
 COAL SEAM(S):COALBURG

FIGURE 11. Plant H Performance

PLANT H

Due to the high ash content of the -0.15 mm x 0 (100 mesh x 0) material, which contains a high percentage of 0.045 mm (-325 mesh) clay fines, tests run with mechanical flotation cells were unable to produce any type of froth. After the installation of the 0.8 m (2.5 ft.) dia. Flotaire, the plant was able to produce an acceptable clean coal product while processing two different feeds with a 50-55% ash range and 55-60% ash range.

CONCLUSION

Lab, pilot and commercial Flotaire Column Flotation applications on fine and coarse coal have demonstrated the Flotaire's capability to improve grade and recovery, even in applications shown to be commercially non-feasible with mechanical flotation cells. Columns, equipped with the froth washing system, can process coal feeds with high contents of fine or coarse clay and produce a saleable clean coal product.

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