

# BENCHMARKING PERFORMANCE OF ERIEZ PHOSPRO COLUMN FLOTATION CELLS AGAINST MECHANICAL CELLS FOR REVERSE FLOTATION OF A SEDIMENTARY PHOSPHATE ORE

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## EXECUTIVE SUMMARY

In this bulletin, flotation columns are compared against mechanical flotation cells for the beneficiation of sedimentary phosphate by reverse flotation.

Eriez performed lab tests using columns and mechanical cells using a variety of ore types from one geographical area and under a variety of processing options. The lab results show a significant improvement in the metallurgical performance (grade, recovery and rejection of impurities) of the columns, compared with mechanical cells.

These results were confirmed in a plant trial of a 0.5 metre diameter pilot column. In this trial, the pilot-scale column was compared directly with commercial mechanical cells. Benefits of the columns included, significantly improved grade/recovery curve, comparable rejection of impurities, fewer number of flotation stages, and less than one third of the overall residence time used for mechanical cells. In production, columns have additional benefits including lower capex and opex and higher availability.

## INTRODUCTION

Two main unit operations predominate in the commercial mineral flotation world, mechanical cells and columns. Each of these technologies operates using different principles, and it is generally accepted that the relative benefits of each technology will depend on the ore being treated (Knoblauch et al, 2017).

Mechanical cells operate by using a mechanical agitator to supply the energy to keep the slurry in suspension, create the fine bubbles necessary for flotation, and create forced convection required to insure good mixing of the bubbles and slurry. They approximate the residence time distribution of a stirred tank, which means there is short-circuiting in the tank, creating the requirement for more units in series. On the other hand, flotation columns have no internal mixers, the residence time is closer to plug-flow, and the mixing of bubbles and slurry is counter-current, which insures optimal contacting in the tank, which means a fewer number of units in series is required. Bubbles are produced with spargers, which separates bubble production from the mechanical action of the agitators. Finally, the plug-flow and counter-current contacting of slurry and bubbles inside the columns allows for the effective introduction of froth washing, which can be used to improve grade. It is generally accepted that mechanical cells are preferred for middling ores (in size and liberation) when high recovery is preferred over grade, such as roughing. When liberation is adequate, columns have significant benefits over mechanical cells. These include lower energy, fewer number of cells (lower capital cost), better selectivity (grade) and lower use of reagents.



Figure 1: The lab columns used for the reverse flotation of this phosphate ore. Also shown here are the mixing tanks and metering pumps for each of the three conditioning reagents.

## DETAILS

### Lab-scale survey

To show the benefits of column flotation for the beneficiation of sedimentary phosphate ores by reverse flotation, samples were tested at Eriez' Central Test lab in Erie PA. Eriez' test lab is a full service metallurgical test lab with capabilities for sizing, crushing, grinding, and splitting. Full assay capabilities (XRF and ICP) are operated on-site to allow researchers to close mass balances for simulating flow-sheets and sizing process equipment.

A variety of ore samples from the undisclosed customer were run to evaluate the grade recovery curve and evaluate optimal process parameters. Figure 1 shows the 75 mm diameter column used for this test-work. Prior to flotation, the ore was conditioned with three different flotation reagents. Conditioner dose levels and mixing times were selected to be as close as possible to the conditions used at site, so the results could be benchmarked against industrial practise. The separation method used was reverse flotation, in other words impurities such as silica were floated away from the product.

The phosphate grade recovery curves for these tests are shown in Figure 2. These results had comparable level of impurities in the product. The column tests are shown in Figure 2 with blue markers. As a benchmark, one test was done with comparable residence time in a batch Denver mechanical cell (black cross) and also with a column operated without wash-water (blue triangle). The process conditions tested in the lab evaluated different residence times and conditioning methods. All of the tests done with wash water are indicated as blue squares. The collective response indicates a fairly typical grade-recovery curve. Both the Denver mechanical cell and the column operating without water show a level of performance below the grade-recovery curve for a column utilizing wash water. All of the lab tests had acceptably low levels of impurities in the product.

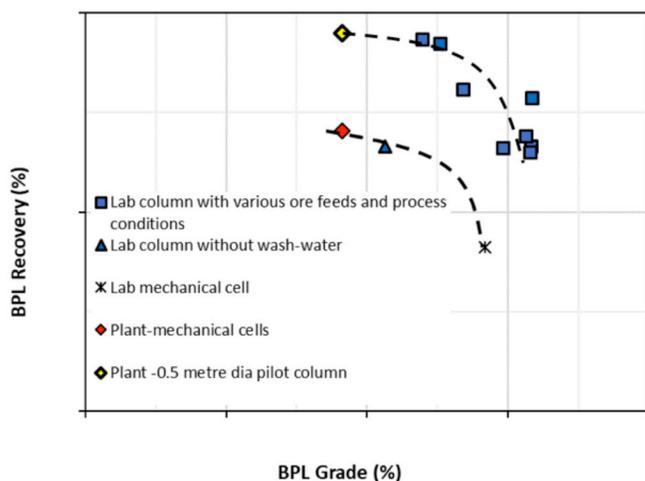


Figure 2: Grade/recovery curve for all tests including lab tests of columns and mechanical cells and plant test of existing mechanical cells and 0.5 metre diameter column pilot.

### Plant pilot test

Eriez also operates a fleet of pilot-scale equipment throughout the world that can be used at site on production ore streams. These tests can be used to benchmark against existing unit operations or to size new equipment for brown-field plant modernizations. Eriez has a global team of process experts who are available to conduct test-work, verify representative plant sampling, run test campaigns and reconcile experimental data using state of the art data reconciliation techniques. It has been shown that data obtained from a 0.5 metre pilot column can be reliably and consistently scaled to an industrial size unit (Knoblauch et al, 2016). A 0.5 metre diameter unit was brought to the plant site

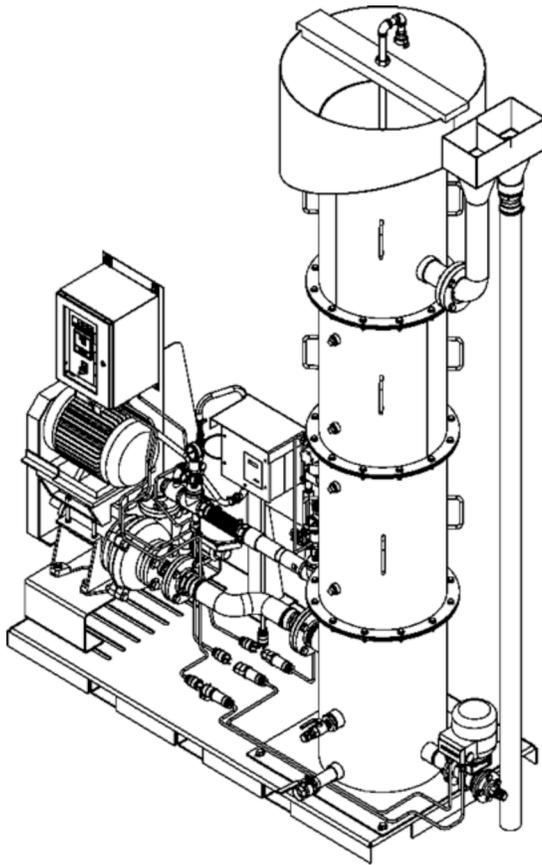


Figure 3: An isometric of the 0.5 metre column that was used to conduct this plant trial. These units can be brought around the world with an experienced Eriez engineer to benchmark or evaluate column performance.

for this operation to run side by side an existing train of conventional mechanical cells. An isometric drawing of the skid mounted column and a photograph of the unit are shown as Figure 3.

This unit was compared directly with the performance of a train of five mechanical cells. Sampling around the bank of mechanical cells and around the pilot column was conducted. Feed for both systems was taken after the last stage of conditioning. During the test, the stability of the flowrate to both systems and the actual flowrate were both monitored and confirmed. Furthermore, percent solids and p80 of the solids size distribution was measured and compared to verify that the sampling did not create any bias in the stream properties going to each system. After sampling, the data was reconciled using a software method that minimizes the sum of the squares of the difference between plant measurements and the constraint of mass continuity. This also allowed an estimate of the “goodness of fit” for the reported results, which were excellent.

The grade recovery curve for the pilot work is transposed on the grade recovery curve of Figure 2. The yellow diamond is the 0.5 metre diameter pilot column, which utilized wash water and the red diamond is the results of the entire train of mechanical cells treated as one block, which did not use wash water. It should be noted that it is not possible to effectively use wash water on a mechanical cell because of the forced convection of the process pulp which is inherent to a mixed tank.

Some other important results of this plant comparison should be reported. The mechanical cells used five stages of flotation whereas the column only used a single stage. The cumulative residence time of the mechanical cells was more than three times higher than the residence time of the column. The recovery, for the same grade was significantly higher for the column. These results illustrate the metallurgical benefits of columns. When the liberation is acceptable, columns can be much more efficient and selective than mechanical cells.

A further benefit around columns is lower operating and capital costs, caused by less energy use and less wear parts. Columns typically have higher availability in operating environments as well. This is because the columns do not need to be taken out of service to maintain or replace spargers, whereas, mechanical cells need to be regularly maintained to replace the rotors, which involves taking the tank out of service.

More questions? Please contact us at [www.eriezflotation.com](http://www.eriezflotation.com)

## REFERENCES

*Knoblauch, J., Thanasekaran, H., Wasmund, E., (2016). "Improved cleaner circuit performance at the DeGrussa Copper Mine with an In situ Column Sparging System", National Meeting of the Canadian Mineral Processors, Ottawa.*



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