# Cleaning columns

**Jaisen N. Kohmuench and Daniel A. Norrgran, Eriez, US, describe new developments in fine coal cleaning due to new column flotation technology.**

The economic recovery of fine coal has traditionally been problematic due to high processing costs and poor separation performance. Over the last decade, however, column flotation cells have emerged as an effective means for recovering the fine coal as a high grade product. The advantage of a column flotation cell over a conventional mechanical cell is the quality of the froth product. Column flotation cells use a combination of a deep froth and a high level of wash water to minimise the hydraulic entrainment of clays, resulting in a high grade coal product. An example of an industrial-scale froth washing system on a column flotation cell is presented in Figure 1.

## Conventional column flotation cells

There have traditionally been two different avenues of approach for recovering fine coal using column flotation. Column flotation cells operate with deep coal froths that allow for the efficient removal of entrained clays. Air sparging systems must be designed to maximise the bubble surface area rising through the column to ensure effective collection and transfer of the fine coal.

When treating deslimed or sized feeds in the range of 0.150 x 0.045 mm (100 x 325 mesh), a SlamJet sparger system is used. The SlamJet technology uses a series of lances that inject high velocity air into the column to create and disperse fine bubbles. A typical column flotation circuit treating a sized feed is illustrated in Figure 2.

When treating coal in a traditional -0.150 mm (-100 mesh) circuit containing a high level of fines, a dynamic sparging system is used. The generation of very fine bubbles is necessary for the effective collection of the fine coal. The fine bubbles are generated by circulating slurry from the column through parallel in-line spargers, into which compressed air is injected. A typical column flotation circuit treating feed material containing a high level of fine material is illustrated in Figure 3.

Figure 1. Eriez column flotation cells illustrating froth washing system. Wash water is applied directly into the coal froth to eliminate clays.

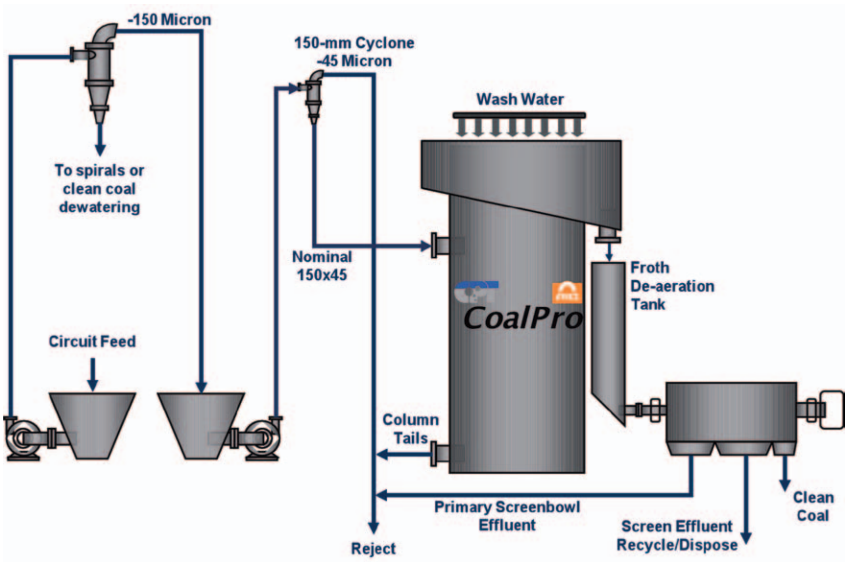



Figure 2. Sized column flotation circuit treating 0.150 x 0.045 mm (100 x 325 mesh) feed. This column flotation cell uses the SlamJet air sparger. The sparger is an air lance that injects high velocity air into the column to create and disperse fine bubbles.

## Multiple column flotation cell circuitry

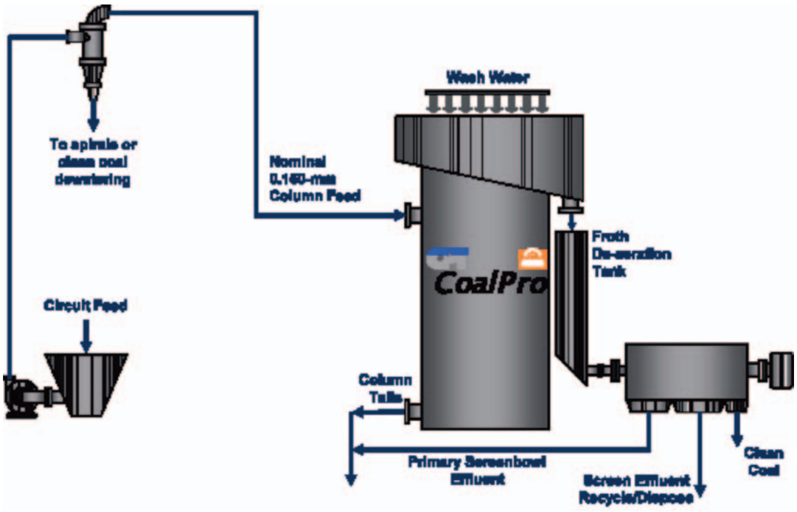
In many industrial applications, multiple column flotation cells are employed in order to meet capacity requirements. The multiple column flotation cells are always arranged as parallel circuits. In simplified terms, each column can treat a specific amount of feed resulting in a finite amount of clean coal carried in the froth product. Doubling the amount of column flotation cells doubles the overall capacity.

Recent studies have determined that the parallel column flotation cell circuit may not be the best approach for meeting the increased capacity requirements.[1] Column cells have become so large that there may be internal short circuiting of feed material. To oppose this potential bypass of feed material, column cells can be arranged in series. In a cell-to-cell arrangement, misplacement is significantly reduced resulting in a more effective separation.

When the column flotation cells are arranged in series, the theoretical maximum recovery of coal, as defined by Levenspiel, is significantly greater than when arranged in parallel.[2] The premise is simple in concept: for an equivalent retention time, a series of perfectly mixed tanks will provide higher recovery than a single cell.

## Challenges

Column flotation has been established as an effective method for recovering fine coal. There are, however, design issues that must be considered for a properly engineered installation. Column flotation cells are typically tall, in order to minimise plant floor space requirements. A tall column flotation cell also provides increased volume to adequately meet capacity or residence time requirements.
The low aspect ratio of the column flotation cell increases foundation loads resulting in additional



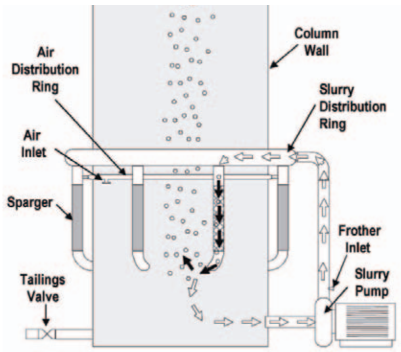




Figure 3 (top and above). Traditional column flotation circuit treating by zero feed. The feed to the column is typically -0.150 mm (-100 mesh) containing a high level of fines. Fine bubbles are generated by circulating slurry from the column through parallel in-line spargers into which compressed air is injected.


Figure 4. 3-D illustration of a StackCell module.

structural steel to support the load. An increase in the diameter of a column flotation cell presents a different set of engineering challenges. The engineering aspects of fabrication, transporation and installation/erection are compounded with a large diameter column flotation cell.

There are also challenges with the metallurgical process when using columns. Deep froth columns on larger cells require increased reagent addition to keep the froth from collapsing. This persistent froth stability creates issues with downstream plant circuits. The column froth launder discharge must be at a sufficient elevation to ensure that the froth can be properly de-aerated and conveyed to the dewatering circuit. In addition, large diameter and relatively short column cells increase the probability of an inefficient use of volume and short circuiting of feed material.

## StackCell™ technology

The issues outlined above illustrate the need for a new generation of flotation cell that provides column-like performance, while minimising the design and operational challenges. Based on experience gained over the last decade with the design, engineering and operation of coal flotation circuits, Eriez has developed a new flotation cell. The flotation cell offers high capacity, a reduction in both size and horsepower and superior metallurgical performance. While column flotation will still be a requirement for some applications, this new approach offers an alternative that provides column-like performance with reduced capital, installation and operating costs.

Figure 4 provides a 3-D illustration of a single-stage StackCell machine. During operation, feed slurry enters the separator through a side-fed feed nozzle, at which point low pressure air is added. The slurry travels into an internal pre-aeration sparging device that provides significant shear and contacting before arrival into the separation chamber. All of the necessary aeration and bubble-particle contacting is conducted in an aeration chamber before injection into the primary tank. The primary tank is used only for the phase separation between the pulp and the froth. Like a conventional column flotation cell, a slurry level is maintained inside the tank to provide a deep froth that can be washed, thereby providing a high-grade float product. Froth is then carried into the froth launder via mass action. These separators are specifically designed to have both a small footprint and gravity-driven feed system that allows cells to be easily stacked in series or placed ahead of existing conventional or column flotation cells. As such, the StackCell successfully integrates key design characteristics of both traditional column flotation and conventional (mechanical) cells.

It has been indicated that several smaller column flotation cells in series maximises the recovery of fine coal in the froth product. The multiple cells perform better than one large column flotation cell representing a total comparable size. Unfortunately, cell-to-cell circuitry is difficult to apply with column flotation cells, due to their tall aspect ratio and large volumetric footprint. On the other hand, the modular design of the StackCell easily accomodates the in-series configuration to take advantage of improved mixing conditions. Therefore, as shown in Figure 5, the preferred arrangement of the StackCell technology is three sequential stages for new installations. Analysis suggests that three cells in series provides a good balance between improving recovery

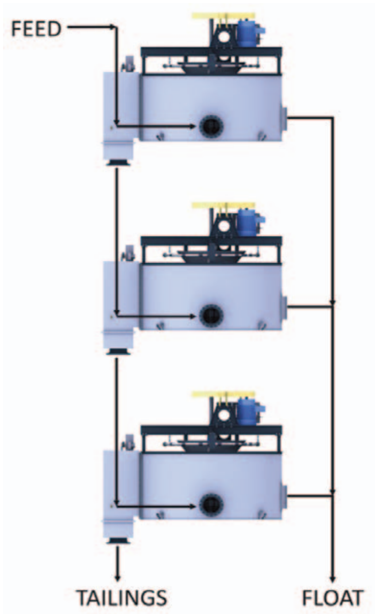



Figure 5. Preferred layout of StackCell flotation modules. Three cells in series. Each cell produces a fine coal froth product.

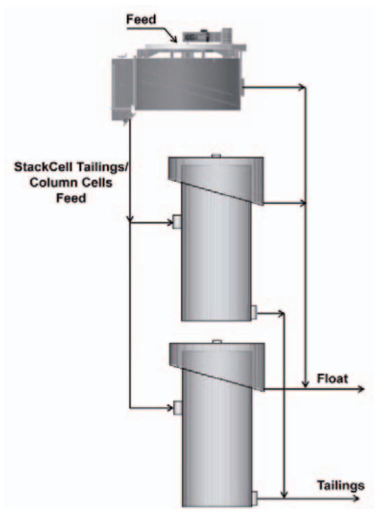



Figure 6. Flotation circuit employing the StackCell as a scalper.

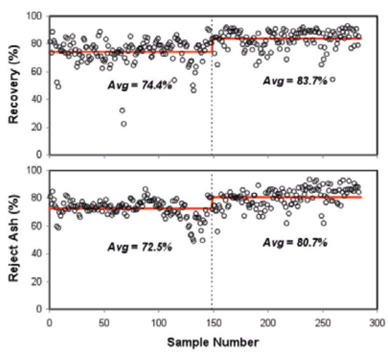



Figure 7. Change in flotation circuit performance due to installation of StackCell technology (dashed line represents sample where changeover occurred).

due to less backmixing and the incremental cost of adding more stages of cells. The technology can also be employed as a retrofit scalping unit placed ahead or behind existing column cells or mechanical flotation machines for additional capacity in the flotation circuit.

A characteristic of the StackCell design is the ability to efficiently pre-aerate the pulp before injecting it into the separation vessel. In this system, the bubble and particle attachment occurs in close proximity to the aeration device and results in an increase in the rate of reaction for the overall process. As a result, there is a corresponding decrease in the required retention time for a given application. This effectively indicates that the same flotation recovery can be obtained in a smaller volume.

The performance of the StackCell technology was recently tested in a full-scale industrial application.[3] The StackCell was installed before two parallel column flotation cells as detailed in Figure 6. Indications were that the two column flotation cells (3 m dia. x 8.2 m high) were overloaded due to production demands. The StackCell was installed as a scalper to produce a high grade froth product, increasing the overall coal recovery of the circuit. The StackCell unit consisted of a single 12 ft dia. cell equipped with a 30 in. dia. aeration chamber. The tailing stream from the StackCell was equally split and fed to the two existing columns.

Figure 7 shows the impact of the StackCell installation on the combustible recovery and refuse ash for the entire flotation circuit. For the first 149 samples taken before the installation of the StackCell, the two column cells provided an average recovery of 74.4% and a combined refuse ash of 72.5%. After the installation, the combined recovery for the StackCell and two column cells improved to 83.7% and the refuse ash increased to 80.7%. The increased recovery is significant considering that less than 10% more cell volume was added to the circuit via the installation of the StackCell technology. In fact, the aeration chamber provided an addition residence time of only about 5 – 10 s to the total flotation circuit.

## Conclusion

The StackCell technology has been developed as an alternative to both conventional and column flotation machines. This technology makes use of a pre-aerated high-shear feed canister that provides efficient bubble-particle contacting.
The result is an increase in the rate of reaction, thereby significantly shortening the residence time required for coal flotation.
Other potential advantages of the process include low air pressure requirements, low capital and installation costs and increased flexibility in plant retrofit applications. Recent full-scale plant trials suggest that the technology can provide coal recoveries and product qualities comparable to column flotation systems using a low profile design. While it is not expected that this new technology will replace the need for column flotation, it does provide an alternate means to efficiently achieve column-like performance when plant space and/or capital is limited. In particular, the small size and low weight of this new technology makes it amenable to low-cost plant upgrades where a single unit can be placed into a currently overloaded flotation circuit with minimal retrofit costs. WC

## References

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