FINE MARGINS

Baojie Zhang, PhD and Paul Brodzik, Derrick Corp., review the importance of the fine coal desliming operation and proposes a new size classification technology.

During the last few decades, the fine coal cleaning circuit has been widely accepted due to technological advancements in size classification technology, coal-ash separation, dewatering, process control, etc.[1] A typical fine coal cleaning circuit, as shown in Figure 1, consists of a fine classification unit (desliming hydrocyclone), separation unit (spiral, Reflux®, flotation), and dewatering unit (centrifuge, filter). The objective of the size classification unit is to provide optimal feed streams to the fine coal separation units (spiral concentrator) as well as ultrafine coal separation unit (flotation). It is well known that coal separation units are effective only over a specified size range of coal particles. The separation efficiency for any coal separator unit deteriorates significantly for coal particles beyond their optimum range. High-efficiency size classification is, therefore, desirable to extract the optimal size feed particles for a particular cleaning unit

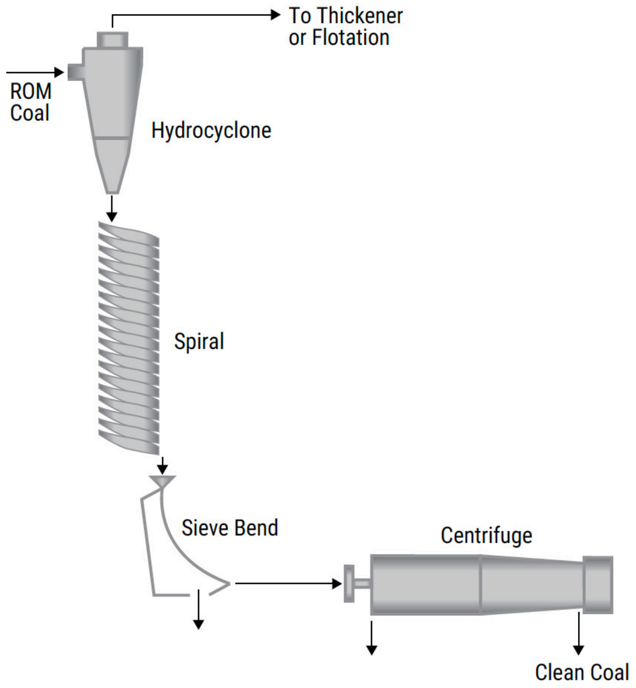

Figure 1. Typical fine coal cleaning circuit consisting of hydrocyclone-spiral-sieve bend.

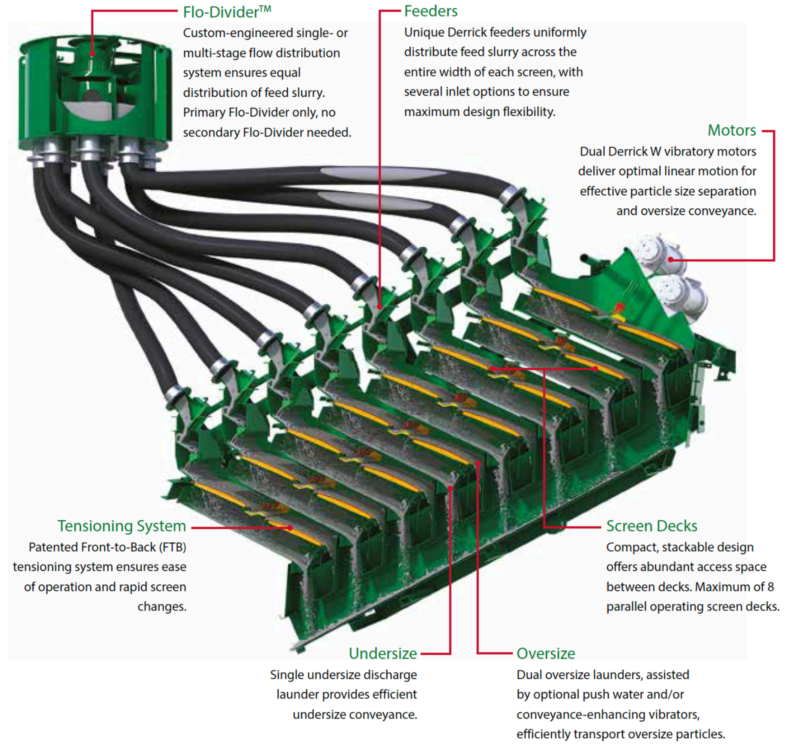

Figure 2. Schematic of full-scale SuperStack with eight parallel screen decks.

operation, for example 1 mm x 150 micron size fraction for coal spiral separators.

Hydrocyclone classification

It is interesting to note that almost all fine coal cleaning circuits use hydrocyclones for the very important sizing or desliming duty. Hydrocyclones utilise centrifugal force to separate coarser or greater mass particles from finer or lesser mass solids. Centrifugal force is generated by converting the delivery head of slurry at the inlet volute into a spiraling passage through the cyclone. Under centrifugal force, coarser or greater mass particles move outward to the cylinder wall and then downward to the apex discharge. Most of the liquid and very fine and light particles are drawn to the core due to less centrifugal force and are then forced upward to the overflow via the vortex finder. The hydrocyclone has been the principal unit of operation for fine coal classification for several decades due to its high mass and volumetric throughput capacity, small floor space requirement, and relatively effective classification. Advancements in cyclone structural design and also in the circuit design have greatly improved the size classification performance for this duty.[2,3] However, the classifying cyclone has two fundamental limitations:

- Fine particles in the underflow due to hydraulic entrainment (fine light coal particles) and density effect (fine high density tailings particles).
- Coarse, light, fine particles in the overflow due to density effect. The misplaced fine particles (high ash ultrafine coal/clay) are often reported to the fine clean coal stream, ending up as contaminants. On the other hand, the misplaced coarse fine particles cannot be effectively recovered by flotation and therefore ending up lost in the tailings.

Classification using screens

Screens are another method of achieving fine particle classification. Static sieve bend screens are widely used in coal processing plants to separate heavy medium from coarse coal and also to dewater, partially to size, the fine coal spiral products. Slurry flows by gravity over the inclined screen surface, where the screen wires are mostly perpendicular to flow. The concave curved screen surface slices away layers of fine particles and slurry liquid.

However, the sieve bend screen tends to be less efficient, have a lower capacity, require higher maintenance, and have high operational costs.[4] Recently developed screening technologies have been proven to be capable of size classification at 150 microns or even finer, while maintaining satisfactory performance.

A study in 2002 evaluated the Pansep screen technology in a pilot laboratory in Southern Illinois University and on site in an Illinois coal processing plant.[3] The experimental results showed that exceptional screen efficiencies could be achieved at a separation size of 45 microns.

However, the Pansep Screen has yet to be commercialised in the US coal industry for a variety of reasons. Meanwhile, Derrick Corp. has commercialised several fine coal screening technologies, including the Stack Sizer® technology and Polyweb® urethane screen surfaces technology. In 2010, a study evaluated the Stack Sizer screen technology at a plant site using both 75 micron and 100 micron urethane mesh panels.[5] High efficiency size separation and ash reduction were achieved using both the 100 micron and 75 micron mesh panel.

Figure 3. FTB tensioning.

A new size classification technology

Expanding on the success of the 5-deck Stack Sizer, the company developed the expanded 8-Deck model, named the SuperStack® (shown in Figure 2). With eight decks operating in parallel and front-to-back (FTB) tensioning system, the unit has up to three times the capacity of similar screen decks (Figure 3). The additional capacity comes with only a slight increase in the space required per machine, reducing the total capital and installation cost, as well as OPEX for any screening installation.

Dual vibratory motors are positioned directly over the upper screen frame to deliver linear vibratory motion to all eight screen decks. The motors have an internal oil lubrication system that eliminates the need for a separate lubrication system, while providing long-term maintenance-free operation and low sound production. Dual oversize launders (one per side) and a single undersize launder eliminates the need for a large hopper, minimising height requirements. Each feeder has a detachable front cover to facilitate maintenance and debris removal. The Flo-Divider™, which equalises flow from the feed source to each deck, is available in a number of discharge outlet configurations from 2-way to 16-way. An optional repulp spray system introduces free water into replaceable rubber wash troughs to help undersize material pass through screen openings.

Customers using the company's product have reported significant capacity increases over their previous screening equipment. These increases are attributed to the rotation of each screen section's crown 90°, parallel to material flow. This change in crown direction assures an even distribution of material across the entire width of the screen and engages 100% of the screening surface. It also minimises migration of oversize particles to the outside edges of the screening deck.

Table 1. Taishan tests summary

Test ID	Machines	Panels	Feed solids	Spray water
1	2SG48-60R-5STK	TH48-30X0.15MT	22.1	No
2	2SG48-60R-5STK	TH48-30X0.15MT	22.1	Yes
3	2SG48-60R-5STK	TH48-30X0.075MT	22.1	No
4	2SG48-60R-5STK	TH48-30X0.075MT	22.1	Yes
5	2W56-60R-8STK	WS56-30X150	20.9	No
6	2W56-60R-8STK	WS56-30X150	20.9	Yes
7	2W56-60R-8STK	WS56-30X75	20.9	No
8	2W56-60R-8STK	WS56-30X75	20.9	Yes

Table 2. Tests results summary

Test ID	Feed			Oversize			Undersize			Efficiency		
	Flowrate	Spray water	Capacity	Yield	Solid	Ash	Yield	Solid	Ash	Oversize	Undersize	Overall
	m^3/h	m^3/h	tph	%	%	%	%	%	%	%	%	%
1	204.4	0	48.4	12.8	57.2	8	87.2	20.2	27.7	92.4	95.3	95
2	204.4	22.7	48.4	9.9	53.9	5.2	90.1	18.7	27.2	88.2	98	97.1
3	90.8	0	21.5	24.1	51.5	9.1	75.9	18.7	30.2	92.8	92.7	92.7
4	90.8	22.7	21.5	19.3	44.6	5	80.7	15.7	29.5	86	97.2	94.9
5	545.1	0	121.7	11.2	61	8.6	88.8	19.3	27.3	86.8	97.2	96.2
6	545.1	36.3	121.7	7.6	54.3	5.7	92.4	18.7	27.1	69.7	98.8	96.2
7	290.7	0	64.9	16.3	59.6	6.1	83.7	18.6	28.6	69	96.8	91.2
8	290.7	36.3	64.9	12.8	53.2	6.5	87.2	17.1	27.7	60	98.7	90.9

This even distribution of material leads to increased panel life by reducing panel wear caused by oversize solids conveying in concentrated areas. Screen panels can be changed extremely fast, typically in less than 1 minute per screen panel. Using a long-handled wrench, the operator turns a rotating tension bar assembly to draw each screen panel into tension. A pawl engages a tooth in the tensioning cam, and a single locking nut is then tightened to secure the applied tension. A full range of the company's Polyweb urethane panels are available for the SuperStack from 53 microns to 1 mm with slotted openings.

Case study

Taishan Resources LLC is a fine coal recovery company in West Virginia, US. Its primary goal is to develop innovative technology to recover fine coal presented in the fine coal tailings pond. Taishan contacted Derrick in August 2019 and discussed utilising the company's fine screening technology for their size classification applications. Understanding that fine screening technology could potentially simplify their flowsheet, Taishan sent representative samples to Derrick's laboratory for industrial scale testing. The objectives were to confirm the screening performance and to optimise the flowsheet. Table 1 summaries the different tests conditions, and Table 2 provides a summary of test results.

While the summary tables are self-explanatory, a few highlights and comments include:

- Both Stack Sizer (Model 2SG48-60R-5STK) and SuperStack (Model 2W56-60R-8STK) achieved satisfactory results, indicated by high screening efficiencies and low oversize product ash contents. The classification performance was much better than the desliming hydrocyclones. The fine screens can process slurry with higher solids, which results in a significant reduction in water-related CAPEX and OPEX, for example, pumping, dewatering, etc. Most importantly, the oversize product ash content was low enough to become clean coal product, thus avoiding investment of additional processing steps at this stage.
- The SuperStack could achieve roughly three times the capacity of a Stack Sizer with the same panel openings. Considering the two units have similar floor space requirements, the total CAPEX requirement for the SuperStack will be significantly less than the Stack Sizer. The OPEX of the SuperStack will also be reduced due to a 75% reduction in time needed to change panels. Preliminary economic analysis of the SuperStack for this application showed that the equivalent capital cost was US$0.223/t, and the operational cost was US$0.012/t.
- For the Taishan phase 1 operation, the company was considering the plant capable of handling 120 tph (or 0.8 million tpy). Therefore, one SuperStack with 150 micron panels was recommended. Two SuperStacks with 75 micron panels were recommended if higher throughput of oversize product is desired.

Conclusion

The coal industry should take advantage of the technological advancement of fine screens. Technology such as that offered by Derrick can help redefine high capacity, high efficiency, fine particle wet screening. Fine coal desliming can not only help produce cleaner coal (sometimes already salable), but it also reduces the CAPEX and OPEX of the entire fine coal cleaning circuit. GMR

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