Advancements in static screen technology for enhanced coal processing applications

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Abstract. Static screens are widely used in coal preparation for desliming, dewatering, and sizing due to their simple operation, low cost, and compact design. However, traditional screens with stainless steel wedge bars face challenges such as material buildup, declining efficiency, frequent maintenance, and high operational costs.Derrick Corporation has introduced an innovative static screen featuring its third-generation surface technology, Trilogy™. This design improves feed distribution and operational efficiency by 10-30% compared to conventional sieve bends, as shown in the data presented in the paper. The new screens also maintain efficiency over time due to better wear characteristics of the synthetic material, which preserve sharp opening edges and support higher capacities through larger open areas and improved flow distribution.Lab tests and field trials in the U.S. have shown significant improvements in screen life, capacity, and profitability. This paper will present lab test data and case studies demonstrating the superior performance of Derrick's static screen technology.

1 Introduction

The Static Sieve Bend (or DSM screen, named after the Dutch State Mines) is an important development in the history of coal preparation, particularly for fine coal dewatering, classification, and heavy medium recovery. By the 1950s, the use of static sieve bends had become widespread in coal preparation plants around the world [1-3].

The DSM screen's key innovation lays in its curved profile consisting of stainless-steel wedge wires, which enhance particle classification. DSM screens typically use stainless steel wedge bars with openings ranging from 0.05 mm to several millimeters, depending on the applications. The slurry is fed tangentially at the top of the screen, and as the slurry flows over the surface, smaller particles pass through the screen openings while larger particles remain on the surface and slide downward. The screen's curvature accelerates the slurry movement, enhancing the separation process. The schematic diagram and wedge wire surface are shown below in Fig. 1.

The static design of the DSM screen results in zero energy consumption and no moving components, which significantly reduces maintenance requirements for coal processing plants due to less dynamic load on the plant structure and no moving parts or vibration in the machine. Due to these advantages, DSM screens quickly gained widespread popularity in coal processing facilities. As coal processing technologies advanced during the 1970s and

1980s, static sieve bends were increasingly integrated with heavy medium cyclones, spirals, and other fine coal recovery technologies. This integration further enhanced efficiency in the separation of ultrafine coal particles, solidifying the role of DSM screens in modern coal preparation processes [4].

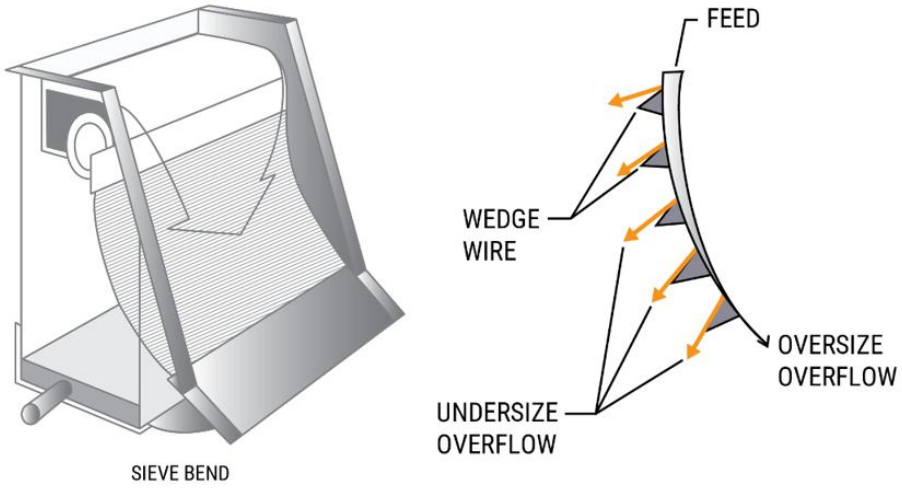

Fig. 1. Schematic diagram of DSM screen and wedge wire surface

2 Limitations and challenges

While DSM screens have become a staple in coal processing, they come with several design and operational limitations that affect their long-term efficiency and overall performance. Some of the common issues faced with DSM screens include:

2.1 Material buildup and blinding

One of the major drawbacks of DSM screens is their susceptibility to material buildup and blinding. Over time, fine particles can accumulate on the screen surface, reducing the open area and thereby diminishing the screen's ability to separate particles effectively (Fig. 2). This often results in lower efficiency and requires frequent cleaning or replacement.

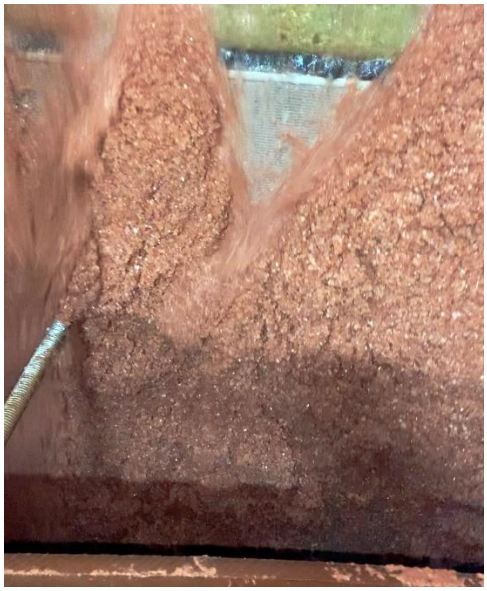

Fig. 2. Solid buildup on DSM screens

2.2 Decline in efficiency over time

The wear and tear on the stainless-steel wedge bars is a common phenomenon to DSM screens. The sharp edges of the openings, which are crucial for effective screening, wear down over time, leading to surface blinding, which results in lower throughput and decreased efficiency, as shown in Fig. 3.

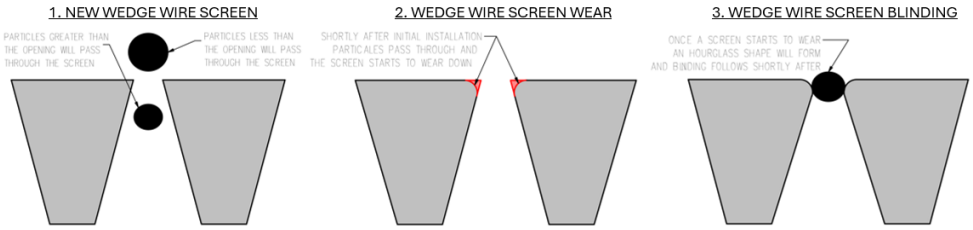

Fig. 3. DSM screen edge phenomenon: sharp edge, wear and tear, and blinding

2.3 High maintenance and replacement costs

The frequent need to clean, maintain, or replace DSM screens can result in significant operational costs for coal processing plants as well as safety hazard for the operators. In some cases, the downtime required for maintenance can disrupt production schedules. Some manufacturers developed reversible housing (Fig. 4) to double the screen life, which helps but still does not solve the problem.

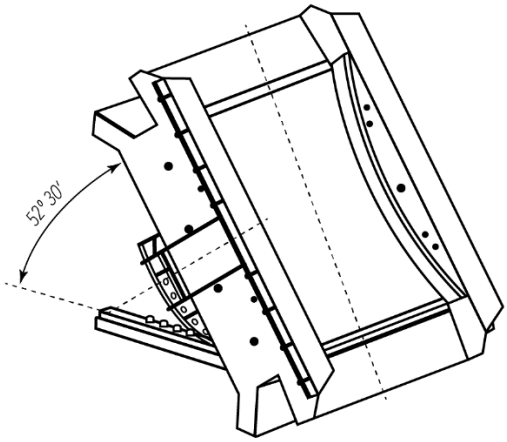

Fig. 4. DSM screen with reversible housing

2.4 Limited capacity

The DSM screens, particularly those with smaller opening sizes, may struggle to handle high-capacity processing. The low open area, due to manufacturing limitations of wedge wire, restricts the screen's ability to handle large volumes. Additionally, the physical size of DSM screens cannot be easily scaled for high-capacity plants. Over time, blinding and wear on the sharp edges of the wedge wire further reduce the effective open area, diminishing the screen's throughput and efficiency, making it a bottleneck in high-capacity coal processing operations.

Due to its inherent limitations, the DSM screen often becomes a bottleneck in efforts to improve plant capacity, clean coal grade, and overall clean coal recovery. Despite this, the DSM screen has received minimal attention from academics, operators, and manufacturers. As a result, there have been few, if any, significant technological advancements in this area over the past 50 years.

3 Technological innovation

Drawing on decades of expertise in fine screening technology, Derrick Corporation has developed the innovative Derrick Static screen, specifically designed to overcome the limitations of traditional DSM screens. The Derrick Static Screen technology utilizes a gravity-fed flow system, eliminating the need for vibration or power draw, significantly reducing operational costs and energy consumption. At the core of this technology is its stackable, curved screen design, which features Derrick's proprietary Trilogy™ Surface Technology. The Fig. 5 shows the Derrick Static screen machine and Trilogy screen surface.

Fig. 5. Derrick static screen and Trilogy screen surface

The modular design of the Derrick Static screen allows for configurations of 2 to 6 stacked screen decks, offering flexibility and scalability for different coal preparation plant setups. This design enables plants to increase capacity without compromising screening efficiency, addressing the bottlenecks that are often associated with DSM screens. Additionally, the screen's lightweight construction and tool-free panel changeout system improve ease of maintenance and enhance operator safety (Fig. 6).

Fig. 6. Derrick static screen panel changeout system

The Trilogy™ surface consists of a highly durable, synthetic material engineered for long-lasting performance, even in the most demanding coal processing environments. Its

unique tapered openings help minimize material pegging, a common issue with conventional DSM screens, ensuring consistent separation efficiency and maintaining high open areas over time. The Trilogy™ surfaces are designed with a much higher open area than conventional wedge wire screens, which allows for increased flow capacity. Fig. 7 shows the open area comparison between Trilogy surfaces and conventional wedge wire surfaces. This high open area enables the Derrick Static Screen to handle larger volumes of coal slurry without sacrificing separation precision, making it ideal for high-capacity coal processing plants. The anti-pegging characteristics further reduce maintenance requirements and extend the operational life of the screen, minimizing the need for frequent cleanings and replacements.

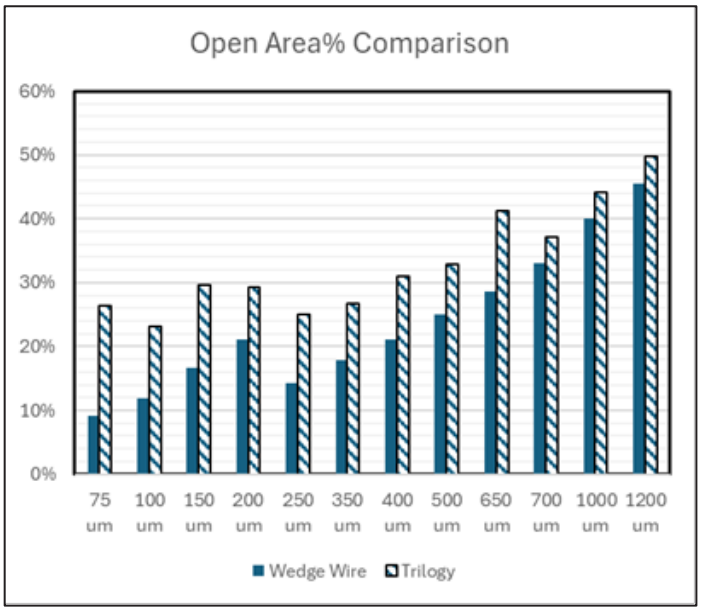

Fig. 7. Higher opening areas for Trilogy surfaces

The modular design of Trilogy™ surfaces offers an efficient solution for retrofitting existing DSM screens, providing a seamless upgrade in screening performance without the need for complete system replacement. Trilogy surfaces can be precisely customized to fit a wide range of screen widths, lengths, and curvatures, making them highly adaptable to various plant configurations. This flexibility allows coal processing facilities to enhance their existing infrastructure with minimal disruption.

Trilogy surfaces also offer significant versatility in optimizing specific applications. Screen openings can be as fine as 53 microns, with customizable slot configurations, including rectangular or square openings, to achieve precise separation requirements. The length-to-width ratio of the slots can be adjusted to tailor flow and separation for different coal sizes and qualities. Additionally, the material of construction can be selected to enhance resistance to wear, high temperatures, and corrosive conditions, further increasing durability and performance longevity. This flexibility in design and materials ensures that Trilogy surfaces can be optimized for diverse coal processing needs, improving both efficiency and capacity while reducing maintenance requirements.

Fig. 8. Trilogy surface (right) retrofitting DSM screen surface (left)

4 Field trial and performance data

4.1 Ultrafine coal screening at 25 microns

An environmental technology company in KY, USA, specializing in the recovery of ultra-low ash value fine coal from coal mining waste faced several challenges with existing processing technologies. The fine coal, essential for producing specialty carbon products such as activated carbon, additives, and fuel oil, must meet strict quality standards. A significant issue in their existing process was the presence of high ash ultrafine particles, which were considered contaminants in the final product.

The company sought a solution to improve the quality of their product by efficiently removing these ultrafine particles. However, existing technologies struggled with poor efficiency and high capital expenditure (CAPEX) and operational expenditure (OPEX) costs. To address these issues, the company reached out to Derrick Corporation for an alternative solution.

Derrick initiated laboratory testing with the Derrick Static Screen using a representative sample provided by the customer. The objective was to assess the capability of Derrick's fine screening technology to remove high-ash ultrafine particles and deliver a clean, low-ash product. The test results, as provided in the mass balance and particle size distribution (PSD) data (refer Table 1and Fig. 9). The undersize efficiency is the percentage of the total undersize in the feed that ends up correctly in the undersize product and the oversize efficiency is the percentage of the oversize material in the feed that ends up correctly in the oversize product. The overall efficiency is the percentage of the entire feed that is correctly classified, i.e.

weighted average of undersize and oversize efficiency. The test exceeded expectations, indicating a highly effective process. Below are the formulae used for efficiency calculations:

A - percent of oversize in the feed;
B - percent of undersize in the feed (100 - A);
C - percent of oversize (coarse) in the oversize product;
D - percent of undersize (fines) in the undersize product.

The weight splits and efficiency values are calculated as follows.

U = Undersize weight (percent) = $\frac{100\ (C - A)}{C + D - 100}$

O = Oversize weight (percent) = $100 - U$

E_U = Undersize efficiency = $\frac{UD}{B}$

E_O = Oversize efficiency = $\frac{OC}{A}$

E = Overall efficiency = $\frac{UD+OC}{100}$

Table 1. Derrick static screen PSD and performance evaluation

Sieve Size		Fractional Percent Retained			Weight Recovery		Efficiency		
Passing (µm)	Retained (µm)	Feed	O'size	Un'size	O'size	Un'size	O'size	Un'size	Overall
	250	0.07	0.1						
250	212	0.14	0.3						
212	180	0.63	1.19						
180	150	2.23	3.07						
150	125	3.55	4.85						
125	106	6.55	8.91						
106	90	9.13	12.48						
90	75	14.08	18.81	0.47	73.78	26.22	99.47	33.99	49.18
75	63	18.6	24.85	0.23	74.44	25.56	99.45	37.7	57.88
63	53	22.86	29.41	0.94	75.9	24.1	99.32	40.69	65.00
53	45	26.27	33.46	0.94	77.47	22.53	99.14	43.46	70.81
45	38	30.66	37.13	4.46	79.05	20.95	98.01	46.03	75.62
38	25	36.59	43.07	14.55	78.83	21.17	94.02	52.34	80.36
	Mean*				76.58	23.42			

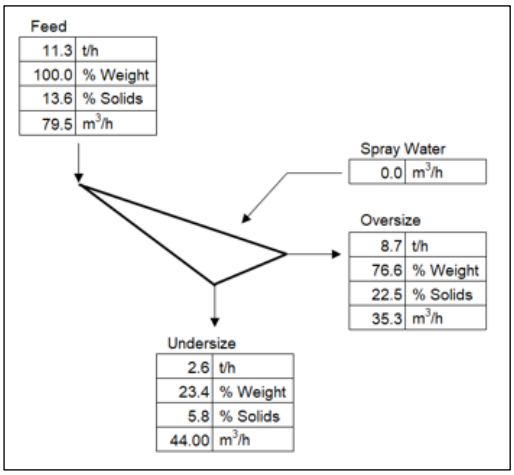

Fig. 9. Derrick static screen mass balance for ultrafine coal screening

Based on the promising lab results, a field trial was commissioned with one unit deployed to the customer's site for further evaluation. After achieving steady state operation, 10 rounds of sampling were collected. The field data demonstrates the unit's effectiveness in removing high ash ultrafine particles and producing low ash clean oversize products.

The clean oversize products consistently showed a reduction in ash value, with an average of 7.2% in the oversize fraction and 9.5% in the feed. The average ash value in the undersize product was 19.5%, more than doubling the feed ash value. The average ash rejection (A.R.) was 38.3%, indicating a significant rejection of ash components. The combustible recovery (C.R.) was 83.3%, which is quite close to the average clean coal yield. This suggests that the unit effectively separates high ash ultrafine particles from the feed. The consistent reduction in ash value and stable yield highlight the unit's capability to produce low ash clean oversize products effectively.

Overall, the field trial shown in Table 2 and Fig. 10 results confirm the unit's effectiveness in achieving the desired outcomes, making it a promising solution for applications requiring the removal of high ash ultrafine particles and the production of low ash clean oversize products.

Table 2. Derrick static screen performance evaluation over sampling rounds

Sampling Round	1	2	3	4	5	6	7	8	9	10	Average
Feed ash %	9.0	8.3	9.2	9.9	9.9	9.4	10.5	10.2	9.7	9.0	9.5
Oversize ash %	7.0	6.6	6.9	7.7	7.5	7.3	7.9	7.6	6.9	6.8	7.2
Undersize ash %	18.0	16.7	19.2	21.5	19.7	19.4	22.6	21.7	18.6	17.2	19.5
Yield %	81.7	83.3	81.8	83.5	80.6	83.0	82.3	81.3	76.3	78.1	81.3
C.R. %	83.5	84.8	83.8	85.6	82.7	84.9	84.7	83.7	78.6	80.0	83.3
A.R. %	36.6	33.6	38.1	35.6	38.8	35.1	38.0	39.8	45.7	41.6	38.3

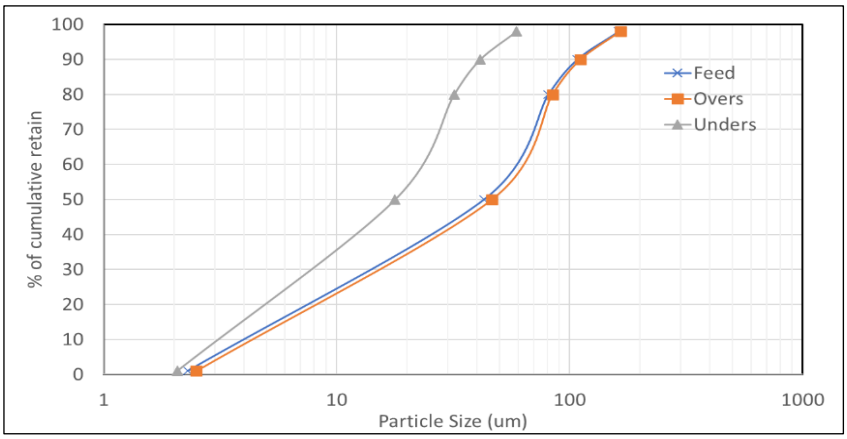

Fig. 10. Derrick static screen feed, oversize, and undersize PSD

4.2 Fine coal screening at 53 microns: an alternative to flotation

The Leatherwood coal plant, a high-grade metallurgical coal operation in Kentucky, USA, is wholly owned by Blackhawk Mining LLC. The Coal Handling and Processing Plant (CHPP) at this site processes 1,000 tons of raw coal per hour. The clean coal product has an average ash value of 7%, with sulphur content ranging from 1.2% to 2.5%, typical for medium-sulphur coals. The plant employs a heavy media separation process, utilizing both vessels and large-diameter cyclones, followed by spirals for fine coal recovery. However, there is no flotation process in place for fine coal recovery from the desliming cyclone overflow (-150 microns), which is currently discarded to the tailings pond. This practice is suboptimal for clean coal recovery and poses an environmental liability.

The tailings pond at the Leatherwood is filling up with fine coal that could otherwise be recovered, increasing the environmental footprint of the operation. The plant technical team identified a gap in their recovery process, noting that implementing fine coal recovery at 53 microns could capture valuable clean coal currently being lost. Although conventional flotation was considered, its higher capital and operational expenses, combined with the need for highly skilled operators, made it less desirable.

Derrick Corporation was approached to provide a solution. Following a series of tests, Derrick's Static Screen technology was evaluated with representative samples from the plant. The test results showed a promising potential to recover fine coal at 53 microns, using efficient screening technology.

In the lab tests, Derrick's fine screen technology successfully captured a significant portion of clean coal that had been discarded. Please see the screen mass balance data and details, particle size, and ash analysis data provided in Table 3 and Fig. 11. Some key data includes:

- Feed: 68.5% ash value, with 0.6% weight passing 100 mesh. The feed slurry solid% is quite dilute at 6.9% w/w, and its volumetric flowrate per machine is quite high at 122.6 m3/h, corresponding to 8.7 tph per screen.
- Oversize: 8.7% ash in the recovered oversize fraction, indicating effective separation of fine coal from high-ash material. Over 90% of the oversize is in the + 44 microns fractions.

- Undersize: 73.4% ash, confirming that the tailings still contain a substantial amount of unwanted high-ash ultrafine material.
- Around 96% of the total ash in the feed is rejected in the undersize

The results highlight the effectiveness of the Derrick Static fine screening technology in reducing ash value while maximizing clean coal recovery. This technology offers a cost-effective alternative to flotation, with lower operational complexity and higher reliability. By implementing this solution, the Leatherwood plant can increase clean coal recovery, reduce environmental liabilities, and improve overall process efficiency.

Table 3. Derrick static screen PSD and performance evaluation at Leatherwood

Sieve Size		Feed		Oversize		Undersize	
Passing (µm)	Retained (µm)	%Wt.	%Ash	%Wt.	%Ash	%Wt.	%Ash
	149	0.6	19.7	7.2	11.2	0.0	0.0
149	74	3.3	4.4	57.8	4.5	0.6	9.1
74	44	4.4	6.6	26.5	3.8	2.3	7.4
44	25	5.3	21.5	2.6	4.8	5.5	23.1
25	0	86.4	77.4	5.9	70.6	91.6	78.5
Total		100.0	68.5	100.0	8.7	100.0	73.4

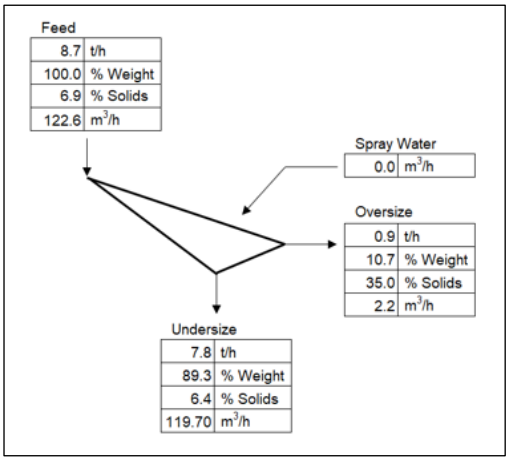

Fig. 11. Derrick static screen mass balance for fine coal screening

4.3 Retrofit DSM screen at 270 microns opening

The Rocklick Processing Plant, owned and operated by BlackHawk Mining LLC, is a high-capacity coal preparation facility in the USA. The plant processes 2,800 metric tons of raw coal per hour and produces metallurgical coal with a product ash value of 9%. The plant uses a heavy media separation process, consisting of primary separation via vessels, intermediate separation using large-diameter cyclones, and fine coal recovery through spirals and froth flotation. One of the critical process steps involves DSM screens positioned after the spiral concentrator and before the flotation system. The DSM screen is tasked with screening at 270 microns (70 mesh) to recover coarse, clean coal before flotation. This step not only enhances flotation efficiency by reducing the load but also prevents low recovery of coarse particles in

the flotation circuit. Therefore, achieving high screening efficiency at 210 microns is critical for the plant's overall clean coal recovery and process optimization.

The original DSM screens in the plant were experiencing some operational issues, for example, high wear, maintenance, and inconsistent performance, leading to suboptimal clean coal yield. The plant's technical team identified the need for a solution to improve coarse coal recovery and address operational challenges.

Derrick Corporation was approached to retrofit one side of the DSM screen with its Trilogy surfaces, a robust and highly efficient screening technology. The Trilogy surfaces were installed to replace the conventional wedge wire screens, with the goals of increasing clean coal yield, improving overall screening efficiency at the 210-micron cut point, and helping to address operational challenges (Fig. 12). The screening performance can be compared with the survey data shown in Table 4 and Table 5. The application here was purely a classification at a cut point of 210 microns; thus, the PSDs and classification efficiencies are shown.

The retrofit yielded outstanding results:

- **Clean Coal Yield**: The Derrick Trilogy surfaces delivered a 5% higher clean coal yield compared to the original DSM wedge wire screens. This significant improvement resulted in increased plant throughput and better recovery of valuable clean coal before flotation.
- **Screening Efficiency**: The overall screening efficiency at 210 micron (70 mesh) improved by 10% for the Derrick Trilogy surfaces, highlighting the superior performance of the retrofit solution in capturing coarse clean coal particles that would otherwise have been lost.
- **Durability**: The Trilogy surfaces have been in operation for over 12 months, doubling the lifespan of the site's conventional DSM wedge wire screens. This enhanced durability has contributed to reduced maintenance costs and fewer operational disruptions.
- **Flotation Performance**: The reduction of the + 210 micron fraction reported in the flotation feed by 11%. This reduces the load of the flotation circuit by the pre-removal of coarse clean coal, adding the flotation capacity and saving the flotation reagents required per ton of coal washing.

Table 4. Wedge wire DSM screen performance evaluation

Sieve Size		Fractional Percent Retained			Weight Recovery		Efficiency		
Passing (μm)	Retained (μm)	Feed	O'size	Un'size	O'size	Un'size	O'size	Un'size	Overall
	250	17.39	92.14	8.77	10.34	89.66	54.78	99.02	91.32
250	212	8.89	2.22	7.9	12.38	87.62	44.44	99.05	84.70
212	180	8.90	1.37	7.89	14.92	85.08	40.59	99.02	78.47
180	150	10.08	0.99	9.65	17.67	82.33	37.77	98.94	71.26
150	106	12.84	0.92	14.91	18.51	81.49	31.11	98.96	59.53
106	38	24.31	0.99	30.7	13.76	86.24	16.46	98.93	30.97
38	0	17.59	1.37	20.18					
	Mean*				14.60	85.40			

Table 5. Trilogy retrofit screen performance evaluation

Sieve Size		Fractional Percent Retained			Weight Recovery		Efficiency		
Passing (µm)	Retained (µm)	Feed	O'size	Un'size	O'size	Un'size	O'size	Un'size	Overall
	250	17.39	91.2	2.02	17.23	82.77	90.37	98.16	96.81
250	212	8.89	2.84	3.65	23.33	76.67	83.47	98.11	94.26
212	180	8.90	1.81	14.17	20.18	79.82	54.99	98.71	83.33
180	150	10.08	0.95	13.76	18.44	81.56	39.44	98.92	72.00
150	106	12.84	0.87	23.08	3.47	96.53	5.83	99.81	45.21
106	38	24.31	0.88	17.00	35.10	64.90	41.97	97.10	51.67
38	0	17.59	1.45	26.32					
	Mean*				19.63	80.37			

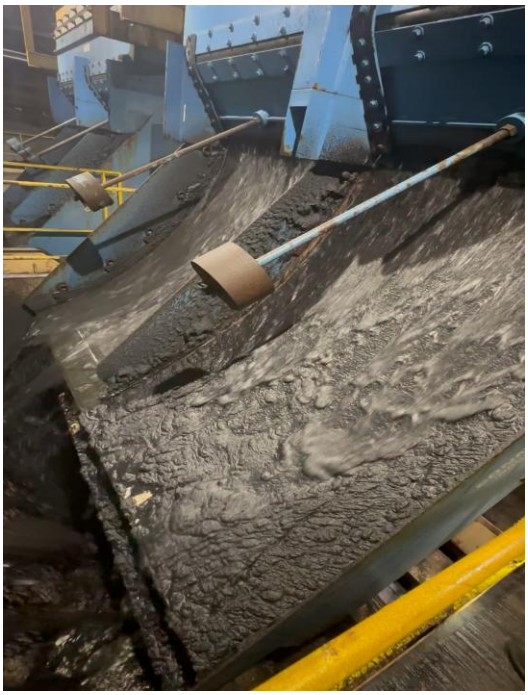

Fig. 12. Operational photo: Trilogy surface (right) retrofitting DSM screen surface (left)

5 Technological innovation

Derrick Corporation's advancements in static screen technology, particularly the Trilogy™ surface and Derrick Static screen, mark a significant improvement in coal processing efficiency. Traditional DSM screens face challenges such as material buildup, declining efficiency, and high maintenance costs, which limit their long-term effectiveness.

The Trilogy™ surface, with its durable synthetic material and high open area, minimizes pegging and maintains separation efficiency over time. The Derrick Static screen, featuring a modular gravity-fed design, enhances throughput while reducing operational costs. Field trials have demonstrated these technologies' ability to improve clean coal yield, reduce ash

value, and extend screen life, making them cost-effective alternatives to traditional flotation and DSM screens.

By retrofitting existing DSM screens with Trilogy™ surfaces, coal processing plants can enhance performance without major system overhauls. The adoption of these innovations has resulted in higher efficiency, improved product quality, and reduced environmental impact. As the industry seeks more sustainable and cost-effective solutions, Derrick's static screen technology offers a compelling path forward, setting a new standard for coal preparation processes.

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