STM Screens – A Productivity Game-Changer ©

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1. Abstract

Two mass screens are high throughput screens that, in the same footprint as an existing brute force banana screen, on an equal comparison basis, claim to handle at least a 30% throughput increase, with the same or better efficiency. They claim to use much less energy to do this bigger task, and to be inherently more reliable. Additionally, the preferred OEM claims the inclusion of their short integral cascading grizzly feed deck (eg 16 mm passing) will produce even higher performance / efficiency gains.

The preferred OEM of this technology has produced two mass screens for decades. In 2005, this OEM redesigned their two mass screens into a modular configuration, in response to demand for larger higher throughput screens. Well over 100 of these new style large screens are in service. With this installed base, the OEM is now looking to move their two-year warranties to five years, expected to occur in the near future.

The principal difference between a two mass and brute force banana screen is that the latter has a one-piece trough deck and support structure whereas the two mass separates the trough deck section and upper 'drive' structure, connecting them with banks of coil springs. The vibrating trough deck on the two mass is lighter so the material on the deck is agitated more intensely to get full activation and good segregation on thicker bed depths, with slower travel speeds. The 'bouncing' action, eliminating sliding, more than triples deck life, despite the heavier loading.

Additionally, the top 'driven' mass is much less, needing less power. Spring separation of the top drive to bottom trough allows a centre rib and uniformly applied force, unlike brute force screens where all force goes through side-plates, leading to premature structural failure risk.

Adoption of this technology started with the first Australian coal installation at a major miner's Qld coking coalmine in mid-2016. Driven by the mine plan approaching low-yielding lesser grade seam/s, they took the opportunity to both process the material at increased throughput and produce a rewashed thermal product. Previously a more expensive 4.2 m wide banana screen conversion was the only possible solution, but now an 800 t/h, 3.6 m x 6.1 m two mass drain & rinse screen is operating very successfully in the rejects stream.

Any new technology has many 'adoption' hurdles to clear. For an industry mindset of 'same Resources, Different World' old paradigms need to be challenged. How do retrofit decisions happen? How design into new plants? Two mass screens permit virtually open-ended design module capacity, easily to 2000 t/h, noting that 5.4 m x 8.5 m two mass screens exist now.

The basic 'business sense' questions are explored herein. Including proof of claims, value, reliability, servicing cost, cultural 'fit', supplier adequacy, process risk / upside potential, feed / despatch capacity, disruptiveness potential, cashflow / bankable adoption strategy, etc.

It is a big topic, with resources included at the end of the paper to expand on what must necessarily be a limited presentation. Whilst technical details are critical, and more needs to be done, the work to date makes a compelling case. The ability of an industry to foster and take on a promising new technology for the benefit of owners and country alike is also an important an aspect, into which this paper will give some perspective.

2. Overview of Two Mass screening technology

2.1. "Why Now?" Relevant historical context & author's experience / observations

When introduced to the Australian coal industry in 2012, a two mass screen's claimed power saving and maintenance attributes were not enough to overcome the OEM's typically double price point. At the time, the assessment of one leading CPP services provider was that 3.6 m screens were working well and 4.2 m screens were almost at the point where their reliability was acceptable. They had no confidence that, if introduced, 4.8 m wide screens were going to be reliable, but would however rely on suppliers to make good on warranties. Regardless of the historical evidence that this approach would ultimately be unsuccessful from an owner's perspective as they most likely dealt with regular warranty related lost production.

The principals of iPUT, a design construct project company having a long history in the Australian coal industry, saw the two mass screen's potential for coal applications, with the main purpose being reliable higher throughput. In 2014, this provider patented the concept and related techniques. Just as the bottom fell out of the coal market, so no miner needed more throughput. In the service provider's journey, the most common phrase heard from industry technical leaders who were across the details was "it's a no-brainer; we've got to do this". Yet action did not follow. Why? Many reasons…

"Where is it, in coal, in Australia?", ignoring widespread uptake elsewhere, is a crippling old-world mindset afflicting the industry. Old funding models of pre-feasibility, feasibility, detailed budget, and complex execution methodologies, contain large overheads of low to no value adding tasks and delays. Making adoption of new tech hard due to self-imposed workloads.

The far more important industry survival question of "How can we best leverage a new tech opportunity for our business and do so efficiently?" consistently remains un-asked in the coal industry. So high profit-generating tech 'out there' remains un-adopted; two mass screens are but an example. Industries that are more progressive focus on 'getting it in and working'.

This is a call to action for the coal industry to find a way to do the same. The old and the new worlds are not at loggerheads; more a cohesive partnership drawing on their respective strengths to find their mojo, overcome inertia, and get some step-changes happening.

2.2. Two Mass screens – Physical appearance and construction

Refer Figs 1 and 2 to explain the basic concepts and Figs 3 & 4 show examples.

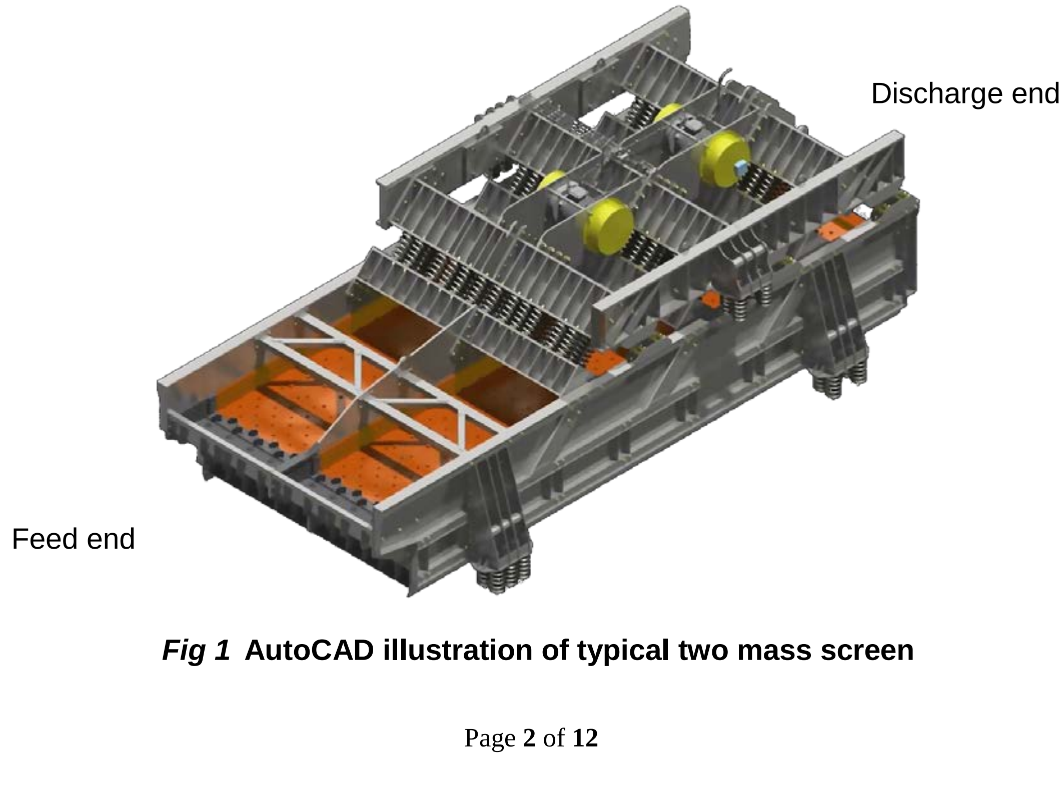

Fig 1 **AutoCAD illustration of typical two mass screen**

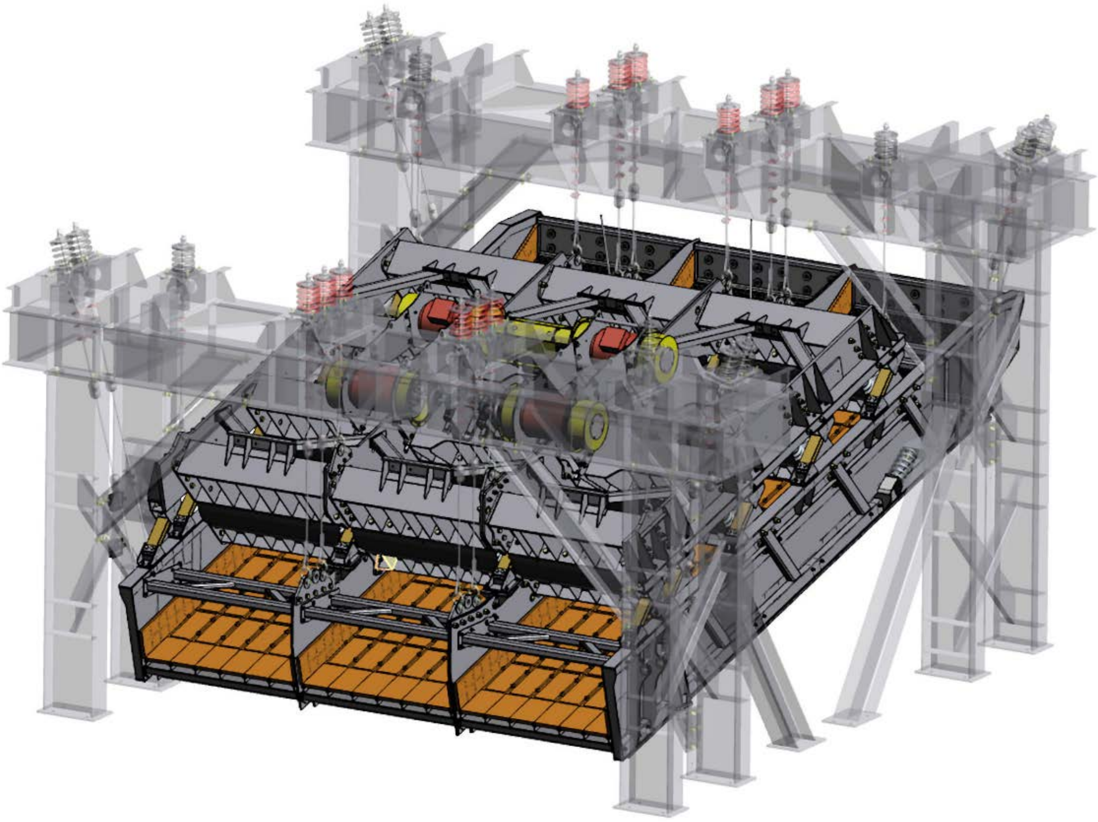

Fig 2 **5.4 m x 8.5 m two mass screen with optional top-hanging system (to simplify below floor level structure)**

Fig 3 **Dahongshan Iron Mine two mass Installation, old style behind (replaced 2010)**

Fig 4 **WA Iron Ore: 8 @ 3.6 m x 8.5 m two mass screens installed 2016, more ordered; Spec 3100 t/h, 2.24 sg, -22 / -12 mm cut, 90% / 85% passing; Operating at 4000 t/h**

2.3. Two Mass screens – Basic explanation of the main benefits

In a typical industry standard brute force screen, the entire screen mass has to move with the screen deck in order to activate material to pass through. Big motors and large forces are involved to activate the material on the deck sufficiently to get the desired result. If the load is increased, the vibration amplitude reduces and efficiency plummets.

On a two mass screen, the exciter (drive) is separate and activates the whole of the trough section much more uniformly. The relatively smaller mass of the trough section has the deck, and this lower mass means higher material activation occurs. Requiring ~50% less total energy to do this much bigger job. Increased load increases vibration amplitude as it moves closer to resonant frequency, so efficiency remains approximately constant.

The two mass screen transmits less vibration to surrounding structure, so is much quieter. For a brute force screen, the whole mass is going up and down, and must see an equal and opposite reaction force at the supports. Sometimes partially mitigated by a damper mass imposed between. A two mass screen has an 'open-shut' style of motion, where the exciter and trough mass' opposite motions largely cancel each other out, so the structure sees less than a third vibration. This can come down to a tenth with a simple phase alignment frame.

On a typical brute force banana screen, deck life is restricted due to the high sliding action wearing out the panels. On a two mass screen the particles may see higher forces for longer (great for screening efficiency), but they tend to bounce their way down the deck. This action is much less deleterious to deck life, despite that the particles have triple the residence time.

Because a Two Mass screen has the exciting load applied evenly across a large area, the stresses in the trough frame are much lower. The design includes a central spine, making the screen much stronger, simplifying modularisation, and allowing easy in-situ reassembly for tight locations with the screen in halves, or in quarters if access is even more limited.

To enhance throughput further, a two mass coal screen has a short cascade deck added to the feed end, so the fines pass straight through and the coarse falls on top of the bed. This quickly establishes the desired stratification for higher efficiencies and ~6 months deck life.

Travel speed being slower means a longer rinse zone, providing further screening efficiency.

2.4. Retrofitting Two Mass screens – Main design issues

A simple overlay of the proposed two mass screen over the existing banana screen outline reveals the need for relocation of the old drive access walkway and possible chute mods. The OEM can typically accommodate the existing feed chute, being the most expensive item to modify. Modified discharge chutes are preferable to changing the new screen's discharge.

The underflow of the two mass screen is straight and a banana screen curved. An infill piece blends the two mass with the underflow launder. This gives some clearance to divert the rinse zone to start earlier. Replacing the underflow launder would give potential to optimise the two mass screen performance further; exactly how much needs more work to quantify.

Two mass screens are a larger static mass, but impose much lower dynamic loads. Any modern CPP design mismatches screen and structural resonant frequencies, with large crossbeams well able to support the additional mass. Building columns are usually adequate, but **may** require plating in where they support multiple heavier adjacent screens.

Rinse water circuits also need examining to ensure adequate supply and that the magnetic separators do not become overloaded. Whilst this is always plant specific, there are many techniques to ensure sufficient rinse water without incurring significant cost.

Upstream and downstream equipment capacity also needs review, eg discharge conveyors.

3. A case study, Queensland coal mine site

3.1. Background

To handle upcoming high ash seams and to recycle coking coal tailings to produce a thermal product, the mine had a need for an increased throughput over a rejects screen, with bed densities down to 1.3 (or circa 1.1 in practice). The existing screen was a lightweight 10 year old brute force 3.6 m x 6.1 m banana screen, rated at 308 t/h but operated to ~650 t/h, soon after which it would trip. Needed throughput was 800 t/h. Avoiding the significantly higher cost of a conventional conversion to a 4.2 m wide screen, the mine decided to install a 3.6 m x 6.1 m two mass as a bolt in replacement. The two mass screen was rated at 800 t/h with <0.5 kg/t magnetite loss, and structurally rated at 1000 t/h at maximum physical bed depth.

3.2. Design process and issues to be accommodated

See Fig 5 for the initial overlay, Fig 6 for the final design adopted and Fig 7 for spray details.

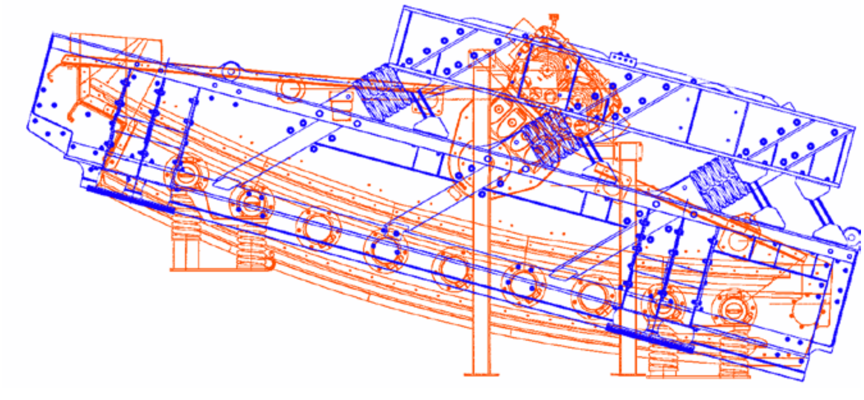

Fig 5 **Overlay of standard two mass screen (blue) on existing banana screen**

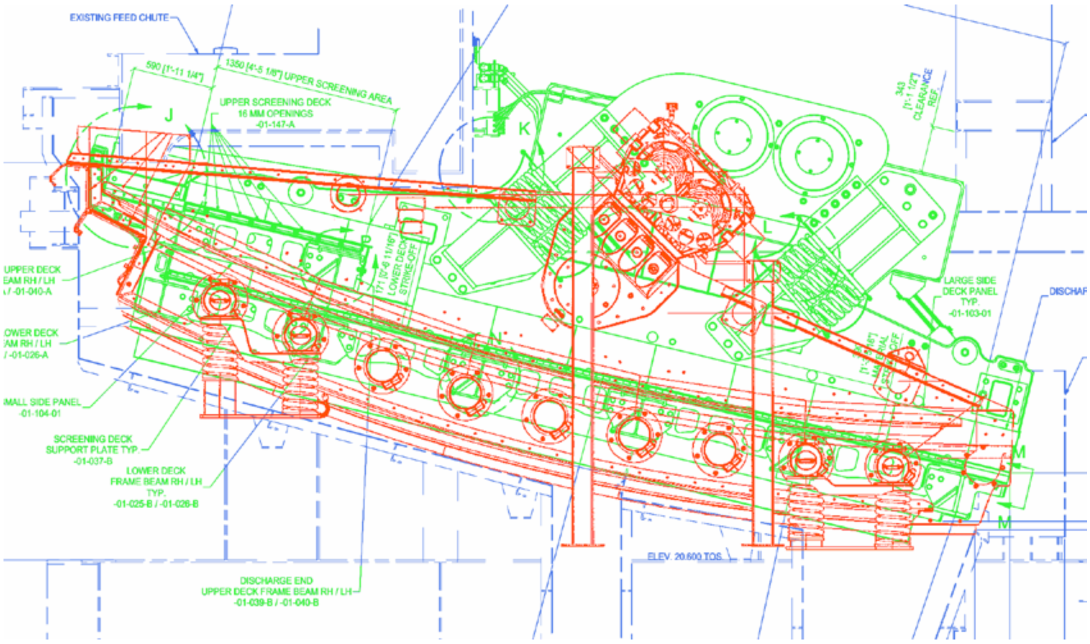

Fig 6 **Overlay of revised two mass screen (green) on existing banana screen**

Note the standard 3 x 2 rows two mass design clashed with the feed box but the revised 2 x 3 rows shorter but taller two mass design now had servicing clearance to the feed box. The OEM had used this configuration on multiple prior designs, but not this wide – later a significant factor.

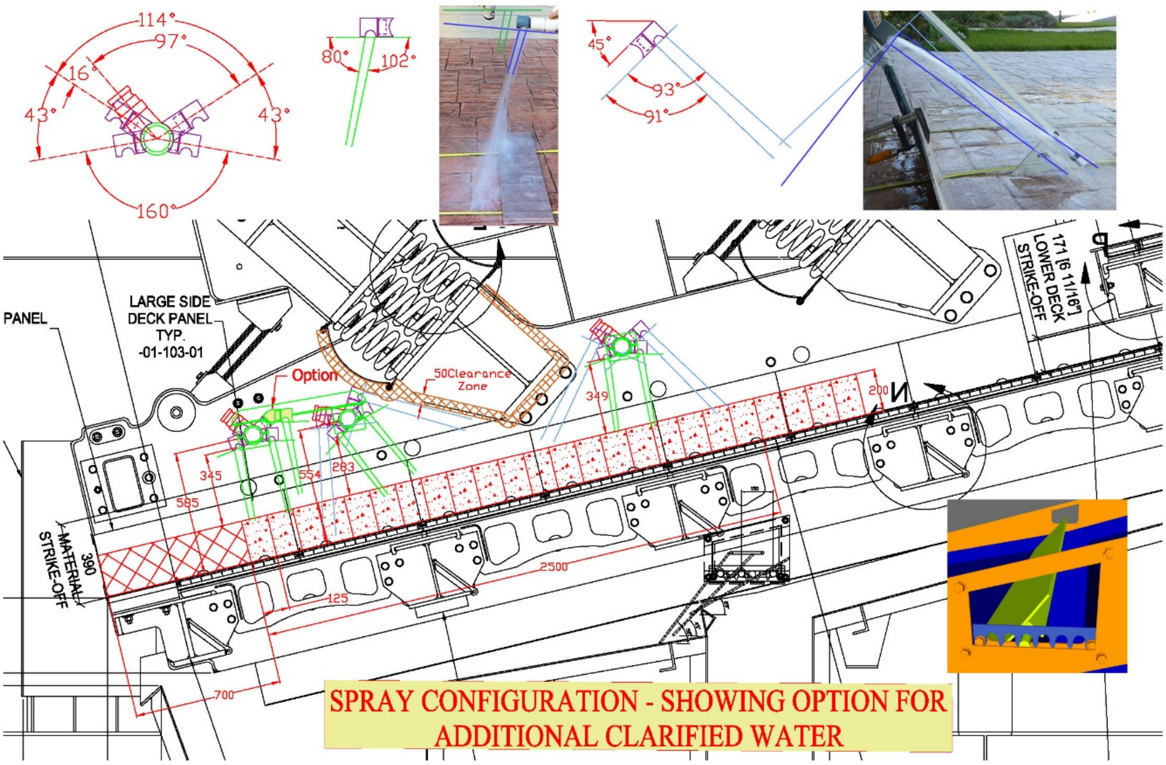

Fig 7 **The science behind developing a new ‘continuous curtains’ spray system**

3.3. Execution, installation & commissioning issues

Generally, this went extremely well. Access was tight, but a novel safe way devised to install the screen and executed flawlessly, on time, no accidents or incidents. The important stuff.

A surprise force majeure event meant the project pre-installation phase carried risk. Thankfully, a two mass screen ships in halves from China for final assembly before transport to site. Flying the components out held the critical implementation schedule, see Fig 8.

Fig 8 **Half of a 3.6 m x 6.1 m two mass screen being loaded for air freight**

Notably there had been no substantial installation projects in the coal industry for some time and that aspect (people being a little rusty) meant site access paperwork was a bigger task than usual. Nevertheless, handled well by those involved. See Figs 9 & 10 for outcomes.

Fig 9 **New two mass screen being inserted horizontally into position**

Fig 10 **As Installed two mass 3.6 m x 6.1 m 800 t/h rejects drain and rinse screen**

The short story of the lessons learned was that nothing could have changed the force majeure event. Reviewing the badly deteriorated state of the old screen against a known delivery schedule, rather than a predicted one, may have allowed better choices. Similarly, reviewing start-up paperwork for efficacy (eliminate wastefulness), and streamlined compliance procedures, would eliminate last-minute effort. However, ultimately this difficult installation went very well. The reasons for that were not lost on the participants!

3.4. Actual Performance

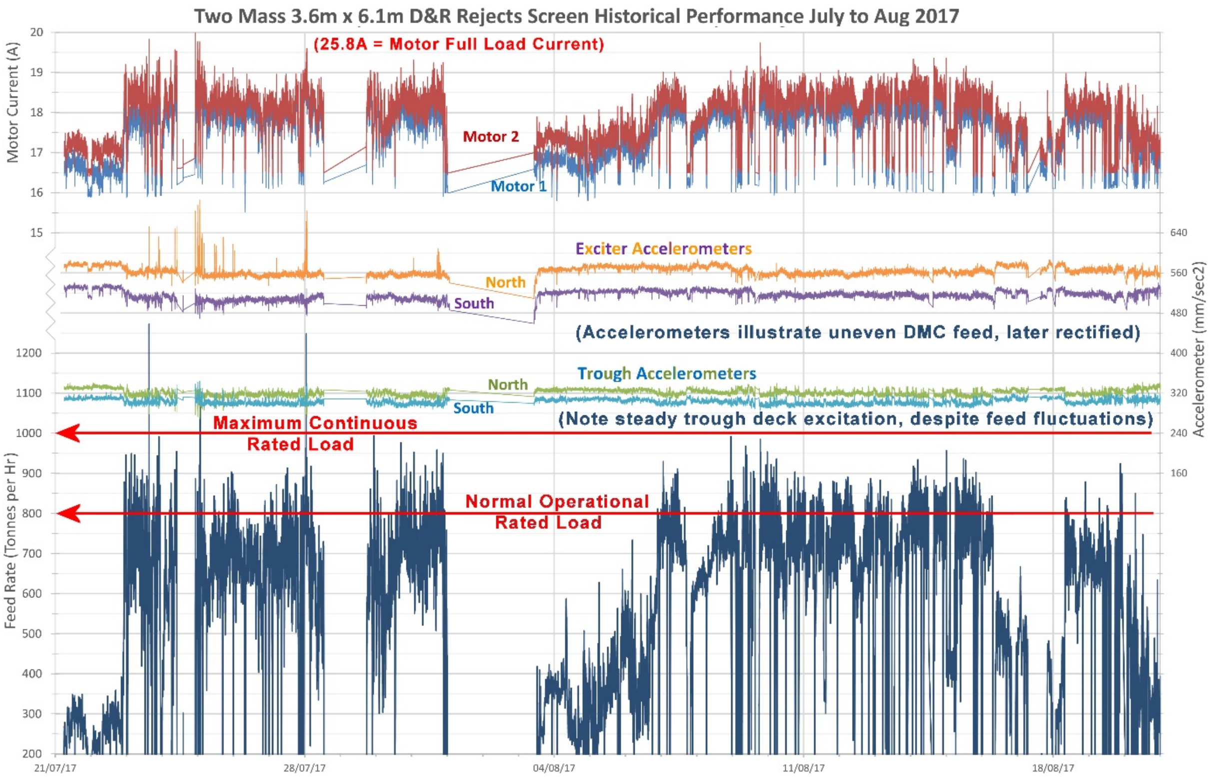

Fig 11 **Typical two mass screen operational parameters during higher t/h periods**

(updated to as-presented, after printing)

In operation, the two mass screen performed as expected; see Fig 11. The cascade section let all the -16 mm material through and formed a bed of fines that the +16 mm then landed on, from a short fall, to cushion the deck panels from impact and stratify the bed in the most desirable way for maximum rinse zone effectiveness. This strategy worked well as spares consumption records show screen deck panel life is triple what it used to be, with 192 days average overall, and 171 / 213 days left / right. Two DMC's feed the screen, causing some variation; a simple flow diverter was later added in the feed box to even out the feed.

Drain water had visibly fully departed from the bottom deck before it had reached the end of the cascade section. Bed depth was constant down the length of the main deck, at around 250 mm depending on density. It took approximately 30 seconds to travel the length of the screen; about triple that observed for the original brute force screen.

Measurement of the two mass screen magnetite recovery verified performance specification compliance. However, magnet wand checks kept coming up clean, so the mine had little interest in doing the work to document actual results.

3.5. Post installation 'teething' issues

Whilst initially the screen performed well, unfortunately teething problems soon occurred. The shorter wider exciter used to avoid costly feed chute mods was vulnerable to a rotational harmonic (as viewed from above). As the machine bedded in, this led to unexpected repairs of initially stiffening, to diagnose the issue, then further work to eliminate the sensitivity.

Modifications included an additional set of exciter slat-ties and a VVVF drive to allow fine-tuning of screen operational speed. This latter proved to be a useful feature to vary operation to suit material density changes, and will be incorporated in future coal installations.

The issues arising were quickly completely rectified. The OEM kept all parties well informed along the way. Whilst the screen continued handling 800 t/h reliably, with magnetite recovery to spec or better, the OEM and Australian participants were unhappy with the reputational blot, since such failures had not previously occurred on **any** of the OEM's screens, ever.

So self-chastising was the OEM at the unexpected issue, they undertook many other tasks that went well beyond any reasonable interpretation of what their warranty obligations were. This culminated in an OEM decision to provide a complete replacement screen. For free!

The installed unit had no recognisable defects, was unlikely to develop any, and was operating to spec. The primary motivation in providing a free replacement screen, complete with all the later developed upgrades, was to ensure a strongly positive reputational outcome for all involved in Australian two mass screen conversions. Has anyone seen that level of supplier response in coal before? Exactly the maturity, and capacity, needed in a technology partner for new product implementations.

3.6. Lessons learned

Spurred on by a need to make up for the teething issue encountered, the OEM undertook a number of rapid product development activities to make absolutely certain the customer was happy with the product and no questions were left hanging over it. Whilst the initial situation was disappointing, the outcome was a screen fully adapted for Australian coal applications, as the mine took the opportunity to ensure robust elimination of any potential niggling issues.

Normally, introduction of a new technology makes a 'list of potential product improvements'. But they were all rectified. Instead, a 'must-have' features list will be part of future supplies. Eliminating things like the OEM's auto-lube system, since it was better to fit in with current mine systems. Better clarity around parallel maintenance activities during initial job planning is an avoidable execution risk in future, eg feed chute repair needs.

3.7. Future potential

Regardless of the exact actual magnetite recovery situation, optimising the rinse zone to suit the screen characteristics could improve magnetite recovery by a significant percentage. Whilst a detailed technical explanation is beyond the scope of this paper, in short, drain water is fully gone by the time the material has left the cascade deck, so a longer rinse zone is possible, and the characteristics of that longer rinse zone deserve careful scrutiny.

4. Full CPP upgrades, an existing mine case study

A big topic. See Fig 12 for outcomes summary and Further Resources for the desktop study.

Generic CHPP Step Change Throughput Increase Suitability Review

Process Overview Calculations

Assumptions

Maximum Possible Annual Operating (365*24) :	8,760	Hours
Current ROM Feed Available:	14,000,000	Tonnes
Target ROM Feed Preferred for Step Change:	24,000,000	Tonnes (=71.4% increase)

						Achievable Range		
Row	Description	Unit	Existing Plant	After +25% Upgrade	After +10Mt Upgrade	After 550t/h Upgrade	After 650t/h Upgrade	Comments
1	Qty Modules	ea	6	6	6	6	6	
2	Coal Feed rate per module	t/h	400	500	538	550	650	
3	CHPP ROM Coal Feed rate	t/h	2,400	3,000	3,228	3,300	3,900	to dump station
4	Increase on existing design output	%	0.0%	25.0%	34.5%	37.5%	62.5%	
5	Assumed operational utilisation	%	80%	85%	85%	85%	85%	increased reliability
6	Annual operational running time	hrs	7,008	7,446	7,446	7,446	7,446	
7	ROM feed capacity pa @85% Availability	t	16,819,200	22,338,000	24,035,688	24,571,800	29,039,400	
8	Actual Raw coal feed available pa	t	14,000,000	22,338,000	24,035,688	24,571,800	29,039,400	
9	Product coal produced pa @ avg 82% yield*	t	11,480,000	18,317,160	19,709,264	20,148,876	23,812,308	
10	Product coal produced pa @ avg 70% yield*	t	9,800,000	15,636,600	16,824,982	17,200,260	20,327,580	
11	Actual operational utilisation req'd	%	66.6%	85.0%	85.0%	85.0%	85.0%	Beyond 85% / 7,500 hrs is a stretch target needing post upgrade work to achieve
12	Annual operational running time req'd	hrs	5,833	7,446	7,446	7,446	7,446	
	* Actual results depend on seam geology					Achievable Range		

Fig 12 **Potential upgrade levels for a typical older style banana screen CPP**

That desktop study was undertaken prior to the Bowen test case, after which it became clear the best-case scenario of 650 t/h would be straightforward to deliver. Ownership issues have delayed further progress, but there is interest and the opportunity remains to increase output for the super low cost of $5/t of annual ROM capacity, with a payback period of months.

5. New installations

5.1. Industry dominating productivity is achievable now

This comes from two general areas. Firstly, the two mass screens can effortlessly go to levels of throughput no conventional brute force banana screen can get near – this is a function of the basic physics. The two mass screens can reliably handle 1900 t/h per CPP module with 4.8 m x 7.3 m two mass screens. Existing screen technology stretches to get to 1200 t/h per CPP module, and it is widely regarded as a consumable item at those throughputs.

The second area of improvement from the high throughput two mass screening technology is the process improvements this enabling technology can unlock, eg reducing cut size to optimise fines circuit performance or adding a separate cut point (extra deck) and additional DMC circuit, in the same physical size screen location, to extract maximum value from fines and course circuits. A new low-ash product also becomes feasible.

Industry leaders have looked closely at high throughput green-field site proposals. Now that the screening throughput issues are resolved, they are very enthusiastic at the potential. Whilst DMC's will need more power, key suppliers advise they will have no problem accommodating the needs. There are hence no apparent obstacles to move to a new paradigm of operational efficiency with industry dominating productivity. Vested interests / politics aside.

5.2. How far could we go?

5.4 m x 8.5 m two mass screens already exist, being installed at a progressive Chinese mine owner's site. The OEM says the modular construction allows them to construct two mass screens up to 6.6 m x 10 m as this is simply 3 @ 2.2 m proven modules. For typical mine parameters, that would likely translate to 2600 t/h per module.

Reducing cut sizes to 0.9 mm or 0.5 mm is a way to take throughput to new levels without fines circuit upgrades. Whilst a two mass screen will handle much more water than a banana screen due to the longer residence period and thicker bed depth, there may be limits. The OEM is at present conducting detailed research into this topic, which is producing exciting results, but they would need NDA's to be in place before divulging any of the work. Nevertheless, this is yet more evidence about how suitable this OEM and their products are for Australian coal CPP's.

The two mass screening technology, and modern thinking around optimal process control techniques, lends itself well to full integration with ioT technology that is sweeping modern manufacturing enterprises with fully business integrated automation. Move coal mines from the inefficient ad-hoc dark ages to a highly efficient substantially automated business enterprise? Only for the nimble few. The tech is there, ready…

The business transformational case does not require the highest possible throughputs, just systematic, automated, reliable, high availability equipment. Plus, an appetite for change.

6. Implementation pathways

For an existing plant, a quick initial feasibility study will validate and quantify the potential. Considerable flexibility exists as to how to proceed from there. A technology licence to use existing resources with suitable oversight may suit some. However, the technology provider already has good partnerships with highly reputed industry majors. Leveraging these via a suitable JV could rapidly implement the technology for a lesser total cost, under a lease arrangement or other suitable design-construct mechanism.

A new plant is similar, except that BOO, BOOT and BOOM, or other options, potentially in conjunction with a selected mining contractor, all become viable.

7. Conclusion – two mass screen summary, and that 'call to action' thing…

Two mass screen technology has been demonstrated to offer an increase of at least 30% in throughput compared to the equivalent footprint brute force screen at the same or better efficiency. This type of screen does so while offering greatly reduced screen deck wear, greatly reduced power consumption, quieter operation, and transmits negligible vibration and dynamic load into the plant structure. Potential also exists to significantly reduce magnetite consumption when used in drain and rinse applications, even at elevated throughput rates.

This OEM has 31 two mass screens installed in Australia over the last 5 years in various industries and styles. Around the world, the OEM has over 150 of the same style of large two mass screens as the case study, and hundreds more including all two mass screen types.

The supplier side team has demonstrated a mature competence introducing new technology to the unique realities of Australian CPP applications, with this step-change productivity improving technology proven ready for scaled uptake. Leading to the open question: "How can we best leverage this new tech opportunity for our business and do so efficiently?".

8. Acknowledgements

Simon Toal, Skala (Director) for his tireless work as the OEM's Aust representative to get the screening technology fully bedded down for consistent high performance CPP use.

Randy Smith, General Kinematics (Vice President, Technical Services) for enthusiastically delivering the product enhancements desired for long-term utilisation of this screening technology in the coal industry, and providing levels of service never before seen in coal.

9. References

Sunter, V 2017, "Step Change Screening Technology", *Central Qld Combined ACARP / ACPS Symposium 2017*, ACPS Emerald, 6-7 September 2017.

10. Further Resources

Summary: **www.iput.com.au/tech/**

Documents:
https://iput.com.au/wp-content/uploads/2017/08/Pictorial_Explanation_of_iPUTs_Step_Change_Screening_Technology.pdf
https://iput.com.au/wp-content/uploads/2017/08/iPUT_Throughput_Increase-OnePageSummary.pdf
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