Vibrating screen designs informed by fundamental parameters

MechChem Africa speaks to Kenny Mayhew-Ridgers of Kwatani about the holistic design approach adopted for its vibrating screens, which involves investigating the process and screening requirements then carefully optimising all the geometrical, physical and dynamic screening parameters.

"When it comes to solving vibrating screening problems onsite or designing a new screen for a client, there are several stakeholders involved in making decisions, each with their own specific area of focus. The EPCM specifies the entire processing line and wants the screening solution to deliver at the correct rates and sizes; the process engineer is looking for efficiency and high recovery rates, while the mechanical engineer is tasked with ensuring reliable operation of the screens and maintaining the equipment with minimum downtime," begins Kenny Mayhew-Ridgers, Kwatani's chief operating officer.

Due to these focus differences, he says, stakeholders do not look at a vibrating screen in the same way. "To have a basic understanding of a vibrating screen requires both process and mechanical insight on the fundamentals of the specific screen type. Without this broader insight, decisions are made that often have a negative impact.

"A process change might trigger a decision to change the screen panels, for example, or the operating speed can be changed in an attempt to improve throughput. Either of these decisions can have a negative effect on the structural integrity of the screen body and/or the efficiency of the screening process," he informs *MechChem Africa*.

Many of the formulas still being used by engineers to design vibrating screens are based on empirical data gathered through funded research at academic institutions. Although of some use, it is evident that much of this data was collected using a very limited set of parameters.

Mayhew-Ridgers, who was himself a researcher at Pretoria University, explains: "Normally a vibrating screen is donated or acquired for test purposes. Such screens have a limited number of adjustable parameters, usually the vibrating speed and the stroke, for instance. By relying on formulas developed in research, screen designs emerge with the same limitations – and there are still many inadequate screen designs in use," he notes.

"Also, the focus tends to be process orientated, with the ore material and screening media being extensively scrutinised. The mechanical performance of the screen and its structure becomes secondary," he adds.

When designing a vibrating screen, Kwatani puts equal emphasis on the ore material; the screening media; the vibrating screen parameters; and the specific application.

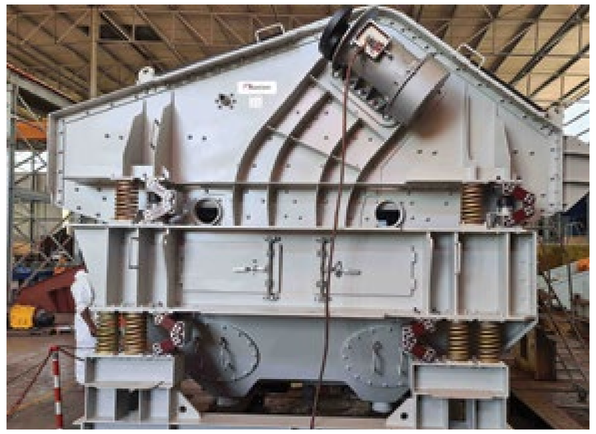
Common screening applications include: scalping; de-watering; drain and rinse; sizing; and de-grit or de-sliming. "These applications are all likely to need different vibrating screen parameters for each of the different ore materials being processed," notes Mayhew-Ridgers, adding that multiple parameters for the ore, screen media and vibrating screen deck have to be considered. These parameters can be categorised as geometrical, physical or dynamic.

"When investigating the effect of the ore material's geometrical parameters, one typically refers to the size distribution and the shape of particles. The physical parameters are the density, hardness, stickiness, abrasiveness, flowability, moisture, clay content, angle of repose and whether it is a wet or dry process," he points out.

For the screening panel or screening media, geometrical parameters refer to the overall shape of the panel: its length, width and thickness. They also consider the screening aperture size, shape, open area and relief angle. The physical parameters include the mass of the panel and the type of material, whether it is a rubber, polyurethane or steel woven wire mesh. The dynamic parameters refer to the flexibility of the panel – in-plane and normal to the panel – as well as the flexibility of the aperture itself.

The vibrating screen's geometrical parameters include the overall length and width of the screen as well as the screen deck angle – horizontal, inclined or declined or even multi-sloped – along with the drive angle and the direction of excitation for linear vibrating screens. The physical parameters are the mass, rotational inertia and centre of gravity of the screen, while the dynamic parameters include the operating speed, stroke, velocity and acceleration, with any two of these parameters defining the other two.

A Kwatani drain and rinse screen manufactured for the coal mining industry.



Left: A smaller Kwatani vibrating screen fitted with torsional springs for the diamond mining industry. Right: The fully adjustable test screen in the Kwatani laboratory for testing of dry commodities.

"When a screen is sized and designed at Kwatani, all these above-mentioned parameters are holistically considered for the specific screening application of interest," he explains.

"Some people get confused by the different vibrating screen technologies: 'brute-force' linear vibrating screens; orbital motion; or twin-mass resonance screens, for example. They think one type of screen has some magical advantage over another. In fact, any screen technologies that share the same set of parameters, should deliver identical results. The only differences might be power consumption and the dynamic loads transmitted through to the support structure," says Mayhew-Ridgers.

"Our first point of focus at Kwatani is the interface between the screen media and the ore material. Neither the motion of the screen nor the type of screen technology matters at this stage. Once the ideal orientation and motion of the screen panel are determined, the deck angle, its stroke and motion, the drive angle for linear vibrating screens or the orbital motion will all follow," he suggests.

The next consideration, he continues, is to look at the screening application in terms of size separation or whether de-watering is required, etc. The ore material properties will drive the panel material choice based on its wear resistance, the flexibility required, the size of the apertures and the open area. The material throughput has an impact on panel loading and the amount of kinetic energy that must be transferred to obtain good stratification. This all influences the required flexibility/stiffness of the screening panel.

The size of the ore particles will drive the required stroke and screen deck angle as well as the drive angle. Large particles normally require a larger stroke to ensure that, if a particle is too large for the aperture, it can be propelled out of the aperture. When the shape of the particle is wedge-like it can easily peg in the aperture. In this case the drive and deck angle can assist. "Some screen designs, especially older designs, incorporate steep deck angles for scalping applications. The thinking is that steeper angles reduce material bed depth and increase the flow velocity. In theory, this should result in higher throughput. Steeply declined decks, however, reduce the screening efficiency, increase panel wear and often result in uncontrolled material flow. To reduce the flow velocity on these screens, the exciters' unbalance can be reduced to reduce the stroke of the screen. But this leads back to pegging," he explains.

Multi-sloped or banana shaped screens for dry-sizing and de-watering applications were originally designed with very steep slopes on the feed end. Again, this leads to a high material flow velocity in that region, with most of the material by-passing the steeply sloping section of the screen.

Many screens of this type suffer failures of the support structure cross-members on the last slope, which has near-zero decline. This is because the reduced material velocity at the end of the screen causes material bed depth to increase, which increases local loading on the screen deck.

Another unexpected overloading issue can arise with drain and rinse screen applications for recovering the ferrosilicon or magnetite used in dense medium separation (DMS) applications. These media have a much higher viscosity than water, so generally require more aggressive screening parameters. Cross-member failures regularly occur, because the loading is not fully understood. The small apertures and the high viscosity cause suction on the downward stroke of the screen, which adds to the cyclic stress components to the cross-members below, significantly reducing their fatigue life.

Numerous successes have emerged by adopting this holistic design approach. Most notably:

- A scalping application where the throughput was increased by over 1 000 tph using the same screen sizes and power consumption. Kwatani-designed panels with optimised flexibility/stiffness were used to increase the kinetic energy transmitted, and improve deck velocity and stratification.
- A drain and rinse application where the modified screen had a three-fold better ferro-silicon (FeSi) recovery due to improved geometrical and dynamic parameters that delivered a more aggressive screen motion.
- A de-sliming application that led to a 20% increase in throughput with the same vibrating screen size, and the screen drew less current than the original installation. Here, the dynamic parameters of the screen proved to make the difference, preventing the customer from upgrading the plant's installed power to accommodate a bigger exciter drive on a heavier screen.
- A de-grit application, where Kwatani designed a new multi-sloped screen of the same size, footprint and power consumption, while avoiding the need for site changes. By optimising the geometrical and dynamic parameters, the throughput was doubled.

"Our founder, Gunter Vogel pioneered the integration of local technology to make the vibrating screens of the time better suited to the harsh conditions on African mines. He quickly established Kwatani as a company focusing on customised, application-specific screen designs," Mayhew-Ridgers tells *MechChem Africa*.

"Not only do we perform finite element analyses (FEA), discrete element modelling (DEM) and computational flow dynamics (CFD), but we also routinely validate the analytical accuracy and real operating parameters using strain-gauged screens on site. This helps us to eliminate guess work and massively reduce structural failures.

"We also have a laboratory equipped with vibrating screen equipment that is fully adjustable to enable us to explore the effect of all of the geometrical, physical and dynamic screening parameters," he concludes. ❑