Mega screens: where materials science meets mechanical engineering

Kwatani business development manager, Annelize Van der Walt (above right), and the company's senior mechanical engineer, Gideon De Villiers (below right), talk about the interactive roles that metallurgy, material science, minerals processing and mechanical engineering play in the design of increasingly large vibrating screens for the minerals processing industry.

"With regard to the design approach for vibrating screens, we believe it is critical to optimise the interactive effects of the ore being processed, the materials used and the mechanical engineering so as to deliver best-fit screening solutions," begins metallurgical engineer, Annelize Van der Walt, Kwatani's business development manager.

"Our customised vibrating equipment solutions are based on 45 years of experience with materials ranging from iron and gold ores to salad leaves and even live worms," she says, adding that this exciting applications range is continually "testing our materials knowledge and broadening our horizons".

"For each and every screen and feeder we design, the processing requirements are matched to ore characteristics such as particle size distribution and flowability, to determine the required screen dynamics and screen media. This is where the practical experience of our diverse team of metallurgical/materials and mechanical engineers plays a critical role in ensuring best possible screening and conveying efficiency for each application," she tells *MechChem Africa*.

Gideon De Villiers, the company's senior mechanical engineer continues: "The place where materials science meets mechanical engineering is on the deck of a vibrating screen. Like a biologist examining the contents of a petri dish, we take a macroscopic view of every screen panel to determine exactly what needs to happen to the differently sized materials flowing over and through the vibrating deck.

"Depending on the ore, we need to determine the optimum aperture size, the thickness needed to minimise wear rates and the screen dynamics needed to move the material on, or to accurately and efficiently size the particles to best suit downstream minerals processing stages," he says.

"We have identified three critical parameters that all need to be carefully considered to achieve optimal results: the ore, the screen panel and the screen dynamics. By looking at individual panels with the material size ranges specified by the mine, we strive to work out how the panel should move to achieve the specified separation result for the ore being mined," he explains.

Critical to this process is Kwatani's testing facilities, where vibrating screen parameters such as drive angle, decline, stroke and acceleration can be adjusted to determine a design starting point.

According to De Villiers, once initial testing has been completed, the next important question is: 'Do we want the same movement and panel properties over all of the screen surface?' "Generally, uniform movement across the deck is perceived to work best, but we have found with wet screening, for example, that water will drain faster when panel vibration is reduced. In a diamond application in Botswana using a banana/multi-slope screen, for example, we shifted the centre of gravity to the discharge-end at the rear to drain the water faster. This raised the vibrating action at the front, causing higher separation efficiency on the dryer material further down the screen," he explains.

The process of scaling up and transferring the 'preferred' parameters to every panel on a screen then begins, "using all the knowledge of screen design we have accumulated over the years".

"Integral to this is Finite Element Analysis (FEA), first to make sure that the screen support structure is going to be strong and stiff enough to achieve the required movement – and the panel material choices have a significant influence on the stiffness requirements of the structure," De Villiers continues.

"Vibrating screen operators who are not achieving the result they need will often try to change the panel apertures and thicknesses, without realising the effect this has on the structure. And while this may work, it is always a good idea to check with the screen OEM that the choice doesn't negatively affect the screen structure and its dynamics" he says.

Van der Walt adds: "When screen panel designs are significantly changed, we can no longer predict or optimise their wear profiles and life. Any change of the screen panel will influence wear and we urge plant operators to consult us as soon as the performance of one of our screens falls off when changes have been made."

RFID Tracer test work being run on the test screen at Kwatani.

FEA is an essential tool when designing equipment subjected to cyclic loading and Kwatani's FEA routines can predict natural frequencies more accurately than ever before. "Depending on operating speeds and total mass, all vibrating equipment has natural frequencies that must be avoided, because a screen will self-destruct very quickly if excited at these frequencies," notes De Villiers. "So we do calculations across the operating frequency range under all loading conditions to see where the natural frequencies fall and what stresses and displacements the screen is likely to experience.

"For the weld and connection stress thresholds on the structure, we have also developed our own fatigue failure criteria from various standard fatigue design codes to ensure that each bespoke vibrating screen can withstand the required conditions," he adds.

Immediately following completion of a bespoke design, Kwatani's fabrication and assembly teams begin work to produce the screen. "We adhere to the highest level of quality to ensure that world-class machines are manufactured. As well as the intellectual property associated with the design, every Kwatani machine has very high levels of local content, significantly exceeding the requirement thresholds of the South Africa's Mining Charter," says Van de Walt.

Each bespoke Kwatani screen is then put though a full factory acceptance test. This is where the FEA results are validated using the company's data acquisition system. Test and measurement data is stored to capture the precise operating performance levels of each machine during the factory acceptance test. A detailed test certificate is issued that captures all the important measurements of each machine, which is then signed off by the design engineer. This can later be compared with measurements taken on site to determine what influence the building structure and run-of-mine ore have on the machine.

"Another recent test campaign involves the use of real-time RFID tracers to track screening performance as mechanical parameters are changed on a test screen," adds De Villiers. "In partnership with another OEM, we have constructed material samples, each with a particular weight, size and shape, which can be put into a working plant to see how each RFID tracer particle moves within the ore body being processed.

A Kwatani-manufactured bulk screen and tube feeder.

"It is interesting to see how these particles mix with the surrounding ore body particles and how they move through the bed depth. We can follow the speed and flow of each particle and accurately quantify the discharge speed of the unit. This enables us to optimise the screen dynamics to make sure that processing speeds accurately match the design," De Villiers explains.

"Often, we get to site and the ore body is very different to that specified for design purposes. So continuous optimisation is as important as initial design to ensure that the expected performance of the screen can be realised on an ongoing basis," says Van der Walt.

"After installation and commissioning is completed by our experienced service teams, feedback from the plant is evaluated against the customer's initial expectations. Our onsite teams can then assist with further optimisation, if required, and are available to perform routine comprehensive on-site assessments and surveys on any other existing plant equipment," she tells *MechChem Africa*.

Mega plants: pushing the envelope

Processing capacity requirements on key equipment such as screens, feeders and crushers have now increased to thousands of tons per hour. Kwatani's bespoke approach stands out with respect to the optimisation and integration of these plant designs. "It is typical for these mega plants to run at a lower cost per ton, but only if reliable equipment is used to ensure low lifecycle costs and minimum downtime. It doesn't help if a plant that can process several thousands of tons per hour sits idle because of unreliability," Van der Walt points out.

One of Kwatani's flagship installations is a scalping screen that can process up to 7 000 t/h of iron ore through panels with 80 mm apertures and a top feed size capacity of 400 to 500 mm. "These screens use Kwatani's own design for the rubber scalping panels, which can withstand the heavy forces and impacts associated with the large top feed sizes. We have also designed, manufactured and installed several 14-foot wide screens. Our approach gives processing plant EPC an easily implementable solution: for single line processing streams; to add redundancy via high capacity standby units; and/or to simplify the associated bulk materials handling systems," she notes.

"With mega plants, it is more important than ever to come up with best-fit design solutions that balance the needs of the ore, the panel materials, the mechanical dynamics and the structural design. We believe our bespoke approach gives us the edge when it comes to implementing robust solutions that offer long wear life and absolute minimum downtime," Van der Walt concludes. ❑