# **Spiral separation for** optimised recovery

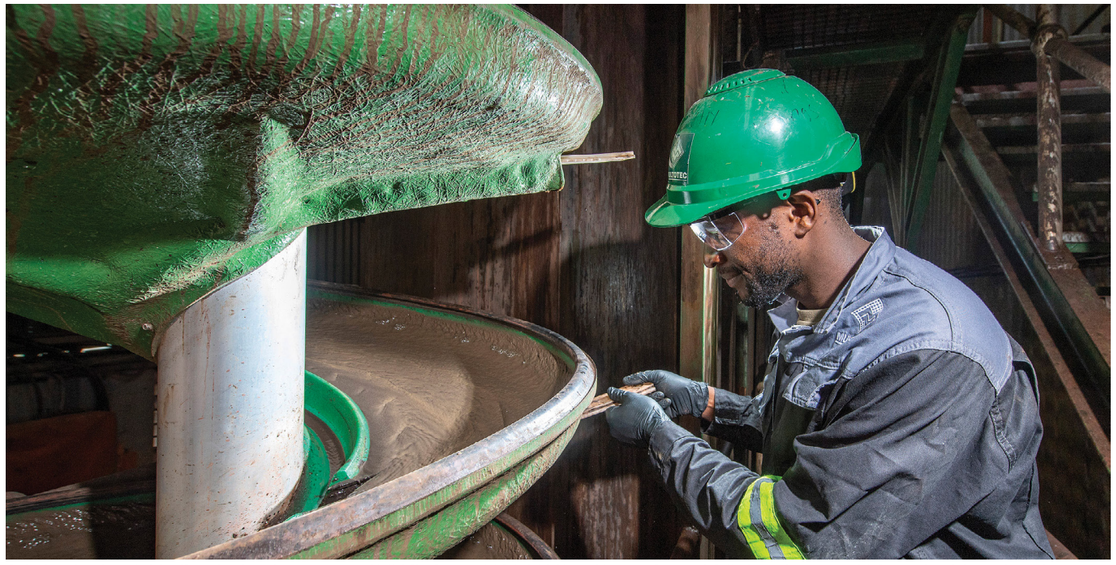
Menzi Xulu, Senior Process and Applications Engineer for spirals at Multotec, talks about spiral technology for the primary separation of minerals, such as chromite, and the upstream concentration of mineral sands. In addition, he highlights their use to extract additional value from the tailings.

Menzi Xulu was sponsored by Mintek to do a chemical engineering degree at the University of the Witwatersrand, so he began his career doing research and development work at Mintek's Randburg research centre. He also worked on commercial scoping and feasibility projects focusing on bench scale and pilot scale testwork on several commodities such as iron ore, chrome, copper, tantalite and mineral sands. He initially joined Multotec as a process engineer for gravity concentration in September 2012 but, in 2014, joined ArcelorMittal Newcastle Works, near his hometown, where he worked on process models for optimising the iron and steelmaking processes. "I returned to Multotec in 2019 and am now a senior process and applications engineer for the company," he tells *MechChem Africa*.

Turning attention to the ideal use of spiral technology, Xulu says that while spirals can sometimes be used as the primary minerals concentration process, there has to be a feed preparation process of some sort prior to separation. He highlights, for example, the recovery of the Middle Group (MG1, MG2) and Lower Group (LG6) chromite ores, which are the richest chromite seams of the Bushveld Complex. The chromite ore must first be crushed and screened into different size fractions. The finely liberated fraction is then mixed with water to form a slurry with a predetermined density. The feed is then deslimed to remove the ultrafine particles prior to spiral concentration.

"We say chromite is a 'heavy' mineral because it has a significantly higher density than the surrounding waste rock, called gangue. Because of this large density difference, spiral technology is ideal for separating out the chromite bearing ore from the surrounding waste, so a high-grade product can be delivered into the ferrochrome industry," Menzi Xulu explains. Spirals can also easily produce other product grades such as chemical and foundry grade sands.

The spiral separation process itself, he explains, is relatively simple and driven by gravity. The slurry is mixed and pumped up to the distributor on top and, as the particle-laden water flows around the spiral, centrifugal forces are created that tend to push particles outwards. The fast settling 'heavies' and larger particles, which are also subjected to drag forces due to contact with the bottom surface, move more slowly so they migrate towards the inside of the spiral flow. The low density materials, on the other hand, which are more easily suspended in the water, are carried by the faster flowing waters on the outside of the spiral's cross section.



*Spiral technology is ideally suited to the recovery of Middle Group (MG1, MG2) and Lower Group (LG6) chromite ores, which are the richest chromite seams of the Bushveld Complex.*

Once the separation pattern has fully developed, tap off channels are used to divert materials of different densities into separate pathways, either for further processing or for sale as high grade ore. So, with chromite ore, the waste is collected from the outside of the spiral and sent to tailings, while the enriched chromite bearing ore will be collected from the inside channels.

"And while the flow regime is quite complex and there are some technicalities and a lot of research involved in selecting the best spiral profile and pitch angles for each commodity, there is general acceptance that spiral technology is one of the simplest separation methods available." says Xulu.

For chrome, the cross sectional profile of the spiral for classification is relatively simple. "Particle size also matters, though, so we tend to narrow the size fraction being processed – typically to 1.0 mm or less – to minimise the amount of chromite fines going to tailings or large pieces of gangue contaminating the value stream," says Xulu, adding that any ultrafine material in the slurry is particularly problematic as it causes viscosity problems, which complicate the flow pattern and impair the efficiency of separation.

With careful design, however, Multotec has developed a new UX7 spiral that enables ultrafine heavies to be recovered. "This spiral is typically employed for reprocessing tailings to recover the valuable mineral that could not be separated out using traditional technologies. The new Multotec UX7 has a flat pitch so as to slow down the material flow, which minimises the suspension of 'heavies' and promotes separation," Xulu explains.

In terms of optimising the parameters to promote separation, he says that, as well as the pitch and the profile of the spiral, the feed density or the solid-liquid ratio is the key parameter that needs to be controlled onsite. Typically, this needs to be between 30% and 50% (weight/weight) for rougher (initial separation) and scavenger (misplaced ore recovery) applications.

Once the recovery has been completed, the value stream is again passed through cleaning and recleaning spirals, which further removes misplaced gangue and raises the grade level towards metallurgical level, typically 42% for chromite ores, which is directly usable in ferrochrome smelters. "We typically start by recovering as much of the product as we can from the feed stream, and then we clean that stream by focusing on removing unwanted material," he says.

As well as for chrome, Xulu says there are other mineral applications, such as for copper, iron and manganese ores, which can be concentrated for metallurgical use using custom designed spirals. "As long as we can access a fine fraction in the minus one millimetre range, spirals can be used to concentrate a wide range of 'heavy' minerals to a saleable grade," he says.

## Upstream processing and mineral sands

While spirals have traditionally been used for processing minerals downstream after mining, the use of the technology for mineral sands applications is largely an upstream separation process used to extract high grades of target minerals and to return unwanted sands to the site.

A wet concentration plant (WCP), explains Menzi Xulu, takes sand directly off the beach, mixes it with the preferred ratio of water and then passes it through a spiral concentrator. Extraction is typically being done several kilometres from the mineral separation plant (MSP), so concentrating the ore deposit at the point of extraction leaves far less material to be carried in trucks. "A lot of the valuable heavy mineral concentrate (HMC) gets extracted and transported to the MSP plant, leaving behind the bulk of the gangue-containing sands at mine site," notes Xulu, adding that directly moving the 'tailings' back into the sea, minimises environmental harm.

The industry standard is to recovery 96-98% of the economic heavy minerals during preconcentration, but recently this has been a challenge because of the declining quality of the resources. To do this economically with relatively low value mineral sands does require a well-designed and hardy spiral concentrator design, and a process philosophy focused more on the recovery of EHM than on maximising the grade of the extracted minerals.

To achieve this, Multotec has introduced the 117HM low grade/high recovery spiral that can reject 90% of the mined material back to the point of extraction in order to transport recovered material containing over 90% of the target economic heavy minerals (EHM). This obviously has benefits; reducing logistic and transportation costs, as well as reducing CAPEX and OPEX for the MSP plant.

The 117HM spiral can be optimised further on site to achieve better recoveries because of externally added features for enhancing grade and recovery. "We are excited that this new spiral has been introduced to the market, our first order of 117HM 12-turn spirals has now been delivered to a mineral sands' operation, and we have recently dispatched three test plants utilising 117HM 8-turn spirals, also to a mineral sands application. Each test plant has a capacity to process 40 TPH of raw feed.

## PMG tailings and the new UX7 spiral

The UG2 ore found In South Africa's Bushveld Complex typically contains several Platinum Group Metals (PGMs). In addition though, chromite ore is also available for recovery from the tailings rejected from platinum concentrators.

Platinum recovery, explains Xulu, involves two stages of milling and flotation (MF1 and MF2). For the MF1 stage, 40% of the particles need to be sub-75 µm before flotation. The heavy tailings from MF1 are then sent to a second mill for further grinding to deliver 80% at sub-75 µm. "The tailings from the Mill-Float 2 stage of platinum processing are therefore very fine, but they are rich in chromite," notes Xulu.

"It is this application that is ideally suited to our new UX7 spiral concentrator, because it is built to accommodate ultrafine feed material," he adds.

Highlighting the key features of Multotec's new UX7 Spiral he says that the pitch has been reduced to decrease flow rates and increase retention times. This counters viscosity effects and enables the concentration of solids in the feed slurry to be increased to 50 to 60% (w/w).


*Multotec manufactures a wide range of spiral sizes and configurations that can be optimised to match most wet slurry applications.*

*Once the separation pattern has fully developed, tap off channels are used to divert materials of different densities into separate pathways, either for further processing or for sale as high grade ore.*

Multotec has been using its one metre wide HX5 spiral for roughing and scavenging of MF2 tailings, with the SC21 spiral being used for the cleaning stages. But desliming the tailings feed in advance of using these spirals is recommended. The UX7, however, can be used to recover the ultra-fine chrome from the slime fines.

"We can also use UX7 spirals as an interstage chrome removal step of the PGM process, extracting as much of the chromite as we can from the MF1 tailings before the PGM slurry is passed through the mill for a second time," Xulu tells *MechChem Africa*. Not only does this interstage approach deliver an additional income stream, it also reduces the volumes being passed to the MF2 platinum circuit, which increases energy efficiency and reduces capacity requirements.

"Optimised recovery circuits are becoming an increasingly important aspect of mining, extracting more value while reducing the amount of energy being used and taking care of the environmental footprint. That is why we at Multotec are continuously looking to develop new products to bring into the market, products that add value, save energy and, ultimately, reduce the cost per ton of mining operations," Menzi Xulu concludes.

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