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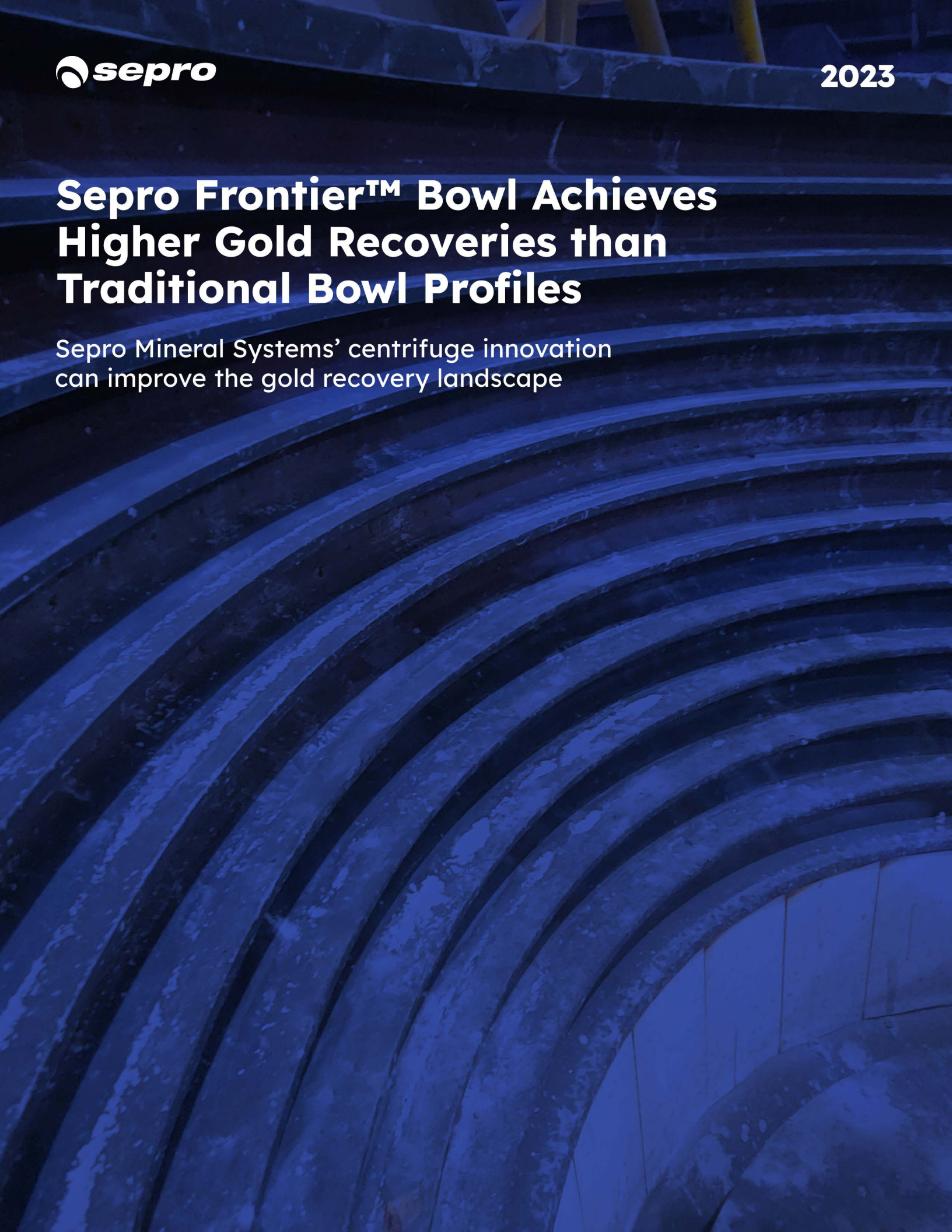
Sepro Frontier™ Bowl Achieves Higher Gold Recoveries than Traditional Bowl Profiles

Sepro Mineral Systems' centrifuge innovation can improve the gold recovery landscape



Modern gold centrifuges have become standard equipment in most gold recovery processes because they are a simple, inexpensive, and effective way of recovering free gold – but like with any process, there is always room for improvement.

Sepro Mineral Systems, Canada's largest mineral processing equipment supplier, has developed the new Frontier™ centrifuge bowl (patent pending). This innovative bowl will soon be offered on all Falcon centrifugal concentrators and as a direct replacement part for most models of the Knelson™ centrifugal concentrator.

Modern gold centrifuges consist of a vertical, rotating bowl with water-fluidized riffles. The high g-force generated by the bowl rotation separates heavy and light particles. The water-fluidized riffles allow the heavier particles to displace the lighter particles and produce a high-grade gold concentrate.

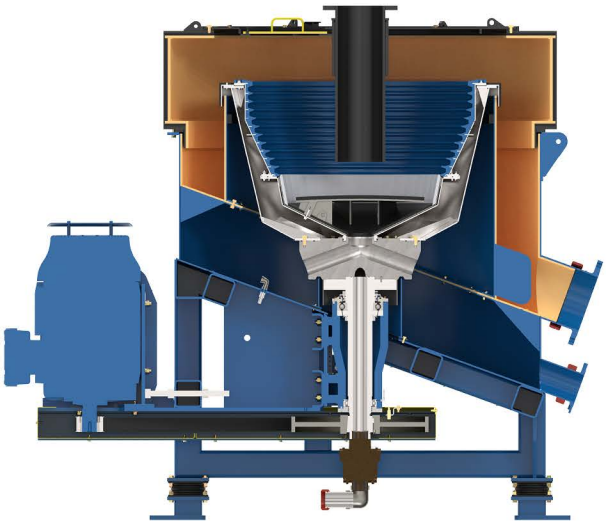


Figure 1: Falcon Concentrator with new Frontier™ Bowl

Figure 2: Modern gold centrifuges installed in a grinding circuit

Benefits to Using A Gold Centrifuge Before Downstream Recovery Processes

- First, gold is removed from the grinding circuit before it is flattened and over-ground, reducing the likelihood of smearing on grinding media or mill liners.
- Second, a high-grade, saleable gold concentrate is typically generated in less than an hour, as opposed to cyanidation circuits where gold inventory can be locked up for days. These factors lead to less gold inventory in the circuit and faster gold payment.
- Third, removing free gold particles and larger gold nuggets from the circuit means that downstream processes receive slurry with a lower and more stable gold grade. The free gold particles typically cause much of the extreme grade variability in gold deposits. Removing the free gold means more stable cyanidation or flotation processes and less reagent consumption. A gold cyanidation or flotation circuit can be run much more efficiently when centrifugal gravity concentrators are installed in the milling circuit. ■

Rich History of the Development of Fluidized Gold Centrifuges

MacNicol patented the first fluidized centrifuge in Australia in the 1930s; however, the equipment was not popularized until the development of the Knelson™ and Falcon concentrators in the 1980s.

The Knelson™ concentrator consists of an inclined, constant-angle bowl wall and fluidized riffles along the entire height of the bowl. This design has been essentially unchanged since the initial development.

The Falcon concentrator began as a near-vertical, smooth-walled bowl specifically designed for fine gold recovery. Over time, the Falcon SB concentrator bowl evolved and now consists of an inclined, smooth-walled separation zone followed by a vertical recovery zone with fluidized riffles. These differences in bowl geometry result in a significantly different concentration mechanism between the two centrifuges.

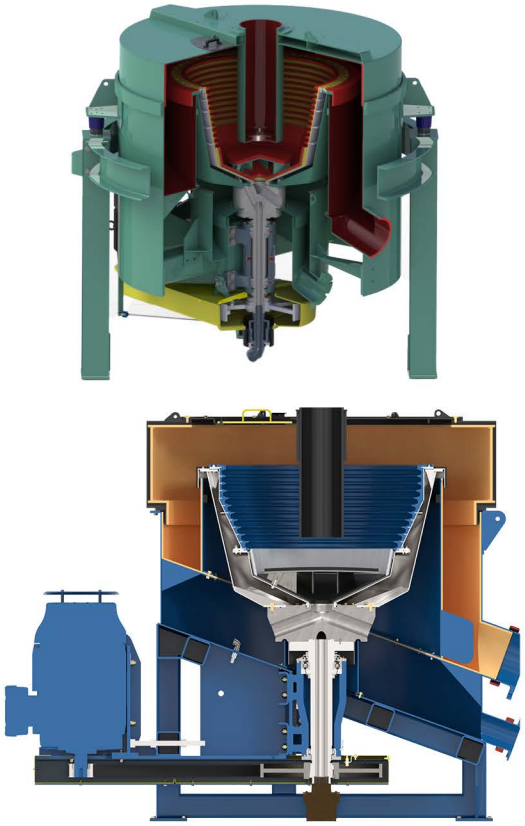


Figure 3: Knelson™ Concentrator (top) and Falcon Concentrator (bottom)

Slurry Profiles

When a mineral slurry is subjected to a centrifugal field, it forms a natural angle of repose based on the slurry density (the relative amount of water and solids) and the particle size distribution in the slurry. We call this the “dynamic slurry face.”

This angle of the dynamic slurry face is typically 5-10 degrees from vertical. Coarser particles and higher density slurry will create a higher angle, while finer particles and a lower density slurry will create a lower angle.

The key difference between the two types of centrifuges is that the bowl angle of the Knelson™ concentrator is shallower than the angle of the dynamic slurry face, while the bowl angle of the Falcon concentrator is steeper. The overall bowl angle of the Knelson™ concentrator is approximately 13 degrees from vertical. Because this angle is shallower than the dynamic slurry face, the slurry can freely exit, and there is no slurry face created in the bowl.

Figure 4: Falcon SB Concentrator in Operation

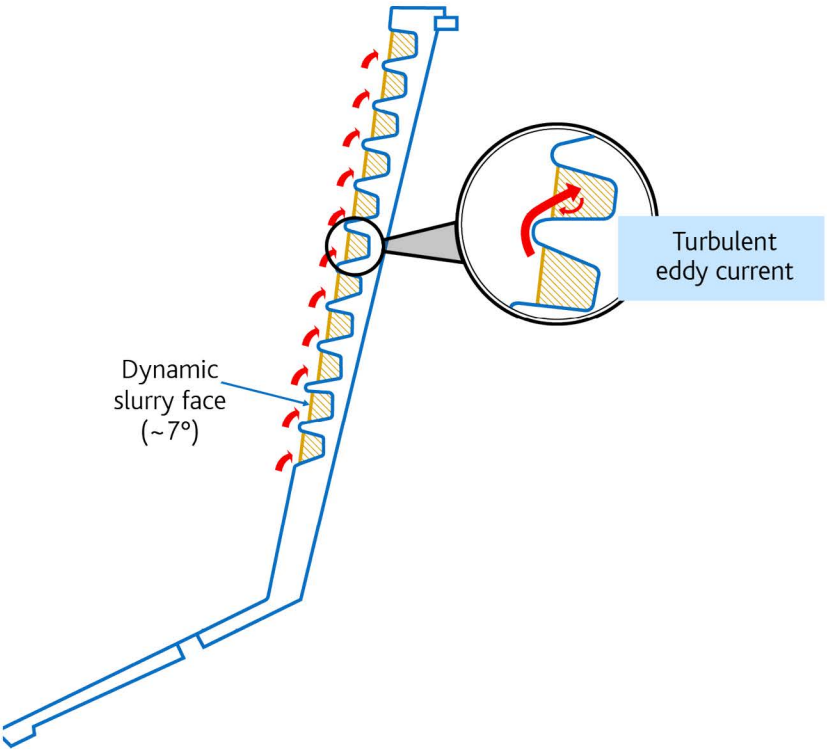


Figure 5: Slurry profile in a Knelson™ Concentrator

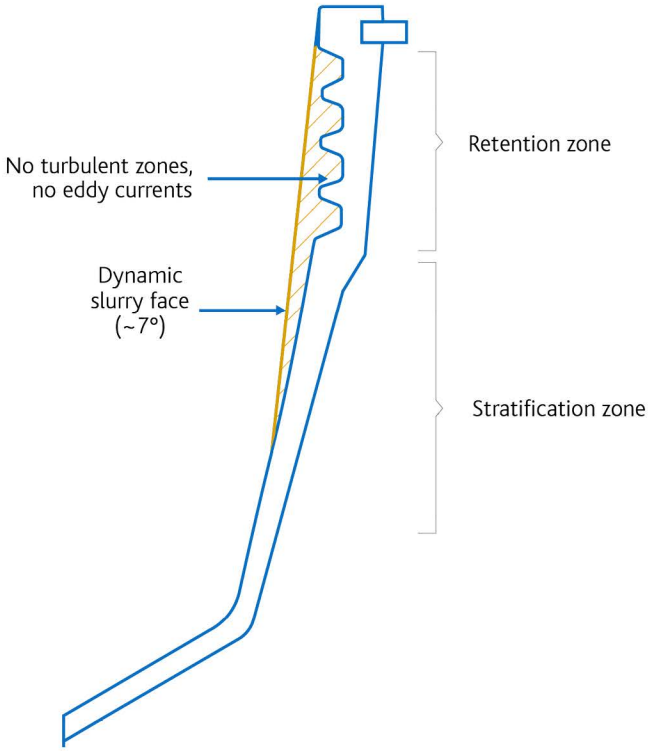


Figure 6: Slurry profile in a Falcon Concentrator

Like the riffles in a sluice box, the Knelson™ riffles create small eddy currents as the slurry falls over each riffle. These eddy currents disturb the material bed and help recover heavy particles over light particles preferentially. As the slurry travels up the bowl wall, the many riffles give the particles many opportunities to be recovered.

The Falcon concentrator has a two-stage bowl, and each stage has a different wall angle. The lower section of the bowl has a smooth, unfluidized wall 14 degrees from vertical. The upper section of the bowl is vertical and contains fluidized riffles.

The lower section of the bowl allows particles to smoothly stratify by density as they move up the wall. Heavier particles are pushed outwards, creating a high-grade zone of particles closer to the bowl wall. The fluidized riffles then capture these high-grade particles in the upper section of the bowl. Because the upper section is vertical, the riffles are behind the dynamic slurry face, and no turbulent eddy currents are created.

These two different mechanisms of gold particle recovery have caused speculation in the mining industry about differences in gold recovery between the Knelson™ and Falcon concentrator. There have been anecdotal reports that the Knelson™ recovers more coarse gold particles, and the Falcon recovers more fine gold particles. However, no one has published any rigorous, controlled experiments at the industrial scale to determine the relative performance of these two types of gold centrifuges. ■

Falcon vs. Knelson™

Sepro's team decided to investigate the gold recovery of each bowl type by testing the Knelson™ and Falcon bowl geometries on a common mechanical platform, the Falcon SB400, at Sepro's research facility near Vancouver, Canada.

The graph on the right shows that the Falcon bowl achieved slightly higher recovery on the low-grade, fine gold-copper ore, and the Knelson™ bowl achieved slightly higher recovery on the high-grade, well-graded gold-silver ore. Both samples' size by size gold recovery analysis indicates that the Falcon bowl is recovering slightly more fine gold particles and the Knelson™ bowl is recovering slightly more coarse gold particles. However, all recovery differences appear to be within the range of experimental error, so it is not possible to definitively conclude that one profile is clearly and significantly outperforming the other at any given gold particle size. ■

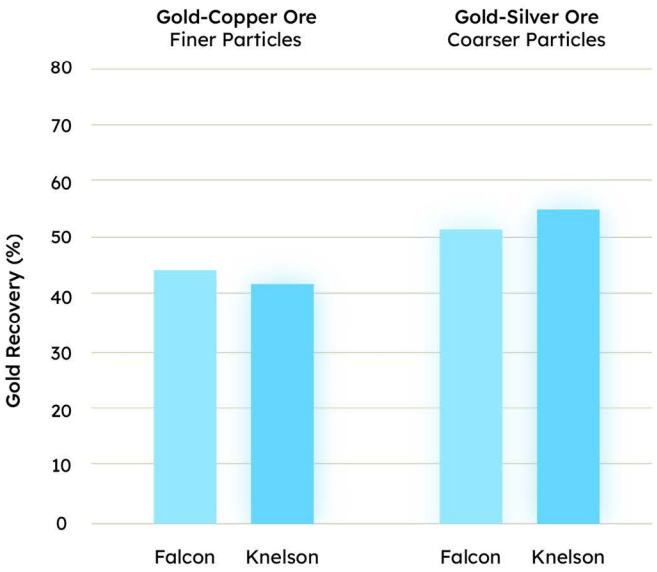


Figure 7: Falcon and Knelson™ gold recovery results

Sepro Frontier™ Bowl

Sepro also tested an innovative new bowl geometry with a quasi-parabolic riffle profile, the Frontier™ bowl. The concept behind the parabolic riffle profile was to create a bowl with riffles on both sides of the dynamic slurry face. We also wanted a smooth path for slurry flow up the bowl wall. Under ideal design conditions, the bottom riffles begin with a relative angle of 30 degrees and progressively decrease in angle until the top riffles are vertical.

Sepro wanted to have riffles on both sides of the dynamic slurry face so that the concentration mechanisms from both the Knelson™ and Falcon concentrators could be utilized.

The bottom riffles are exposed to the slurry flow, creating a turbulent eddy current concentration zone. The top riffles are not directly exposed to the slurry flow, creating a relatively quiet zone of particle separation and recovery. In between is a transition zone where the angle of the bowl wall is equal to the angle of the dynamic slurry face.

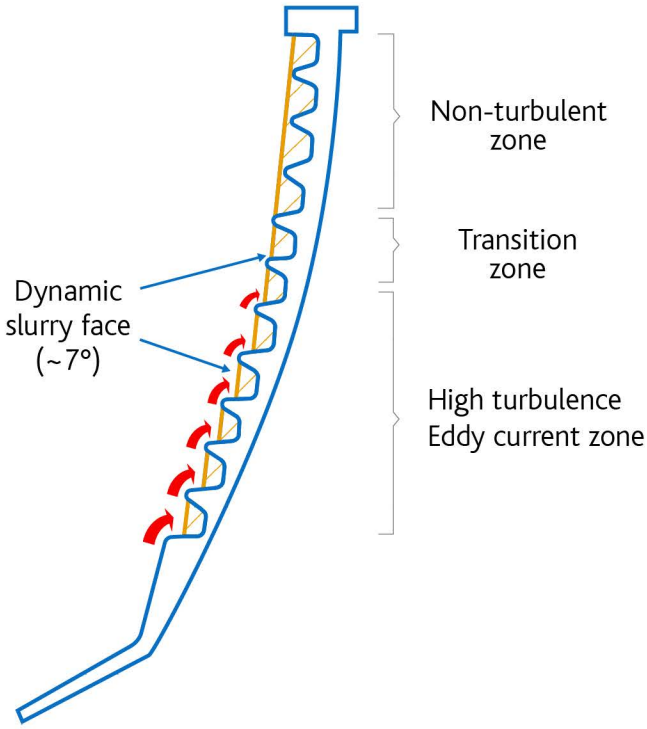


Figure 8: Slurry profile in a Sepro Frontier™ Bowl

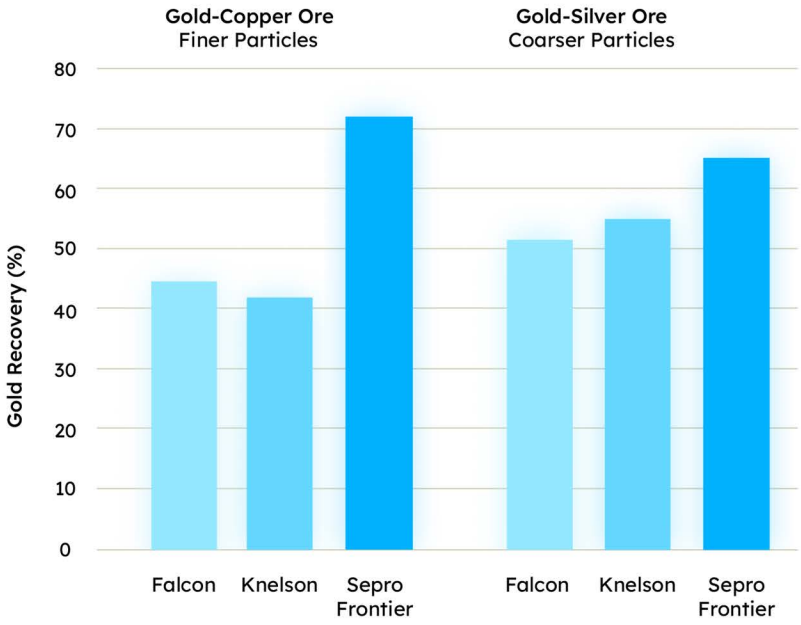


Figure 9: Sepro Frontier™ Gold Recovery Results

The Sepro Frontier™ bowl profile achieved significantly higher recoveries than the Knelson™ and the Falcon bowl profiles. It achieved almost 20% higher recovery on the high-grade ore with coarser gold particles (65% vs 55%) and almost 50% higher recovery on the low-grade ore with finer gold particles (65% vs 45%). The size by size gold recovery analysis identified improved recovery across a range of gold particle sizes with dramatic and consistent recovery improvements in particle size ranges below 100 microns.

The Frontier™ bowl achieved these recovery improvements under all test conditions. From this information, we can infer that combining both concentration mechanisms (along with a smooth transition zone) dramatically improves overall gold recovery across a range of ore types, gold grades and particle sizes.

Industrial Trials

Based on the significantly higher performance of the Frontier™ bowl in the Falcon SB400, Sepro decided to proceed with comparative testing in an operating plant environment. Sepro produced a Frontier™ bowl that fit as a direct replacement part in a Knelson™ XD48 gravity concentrator. The bowl was installed at a gold mine in North America currently operating two Knelson™ XD48 gravity concentrators with the standard Knelson™ riffle profile. The Frontier™ bowl was installed in one XD48, while the other used a standard Knelson™ bowl. Trials were run with the Frontier™ bowl and the Knelson™ bowl, each operating independently to compare the two profiles directly at the industrial scale.

Tests were run on each bowl over two days, using the standard plant settings for feed rate, bowl speed, fluidization flow rate, and concentration cycle times. With the Knelson™ bowl installed, the gravity circuit achieved an average gold recovery of 18%. With the Frontier™ bowl installed, the gravity circuit achieved an average gold recovery of 54%, representing a relative increase of 300%.

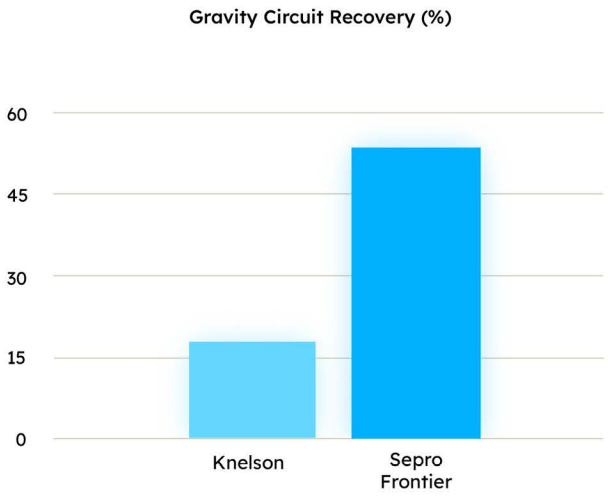


Figure 10: Frontier™ vs Knelson™ Plant Trial Results, Gold Recovery

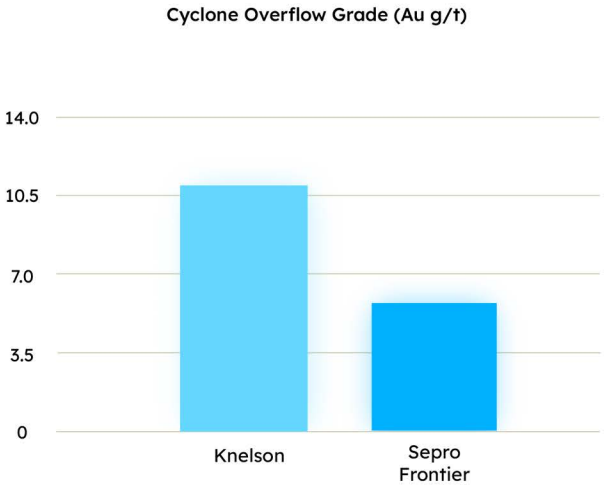


Figure 11: Frontier™ vs Knelson™ Plant Trial Results, Cyclone Overflow Grade

The variability in average feed grade between the two trials was approximately 10%, with the Frontier™ tests experiencing a slightly higher feed grade. Despite the higher feed grade, the Frontier™ bowl generated a lower cyclone overflow grade, further demonstrating that the Frontier™ bowl removed more gold from the grinding circuit.

The standard Knelson™ bowl achieved a cyclone overflow grade of 11.0 g/t Au while the Sepro Frontier™ bowl reduced the cyclone overflow grade to 5.8 g/t Au, a 47% improvement.

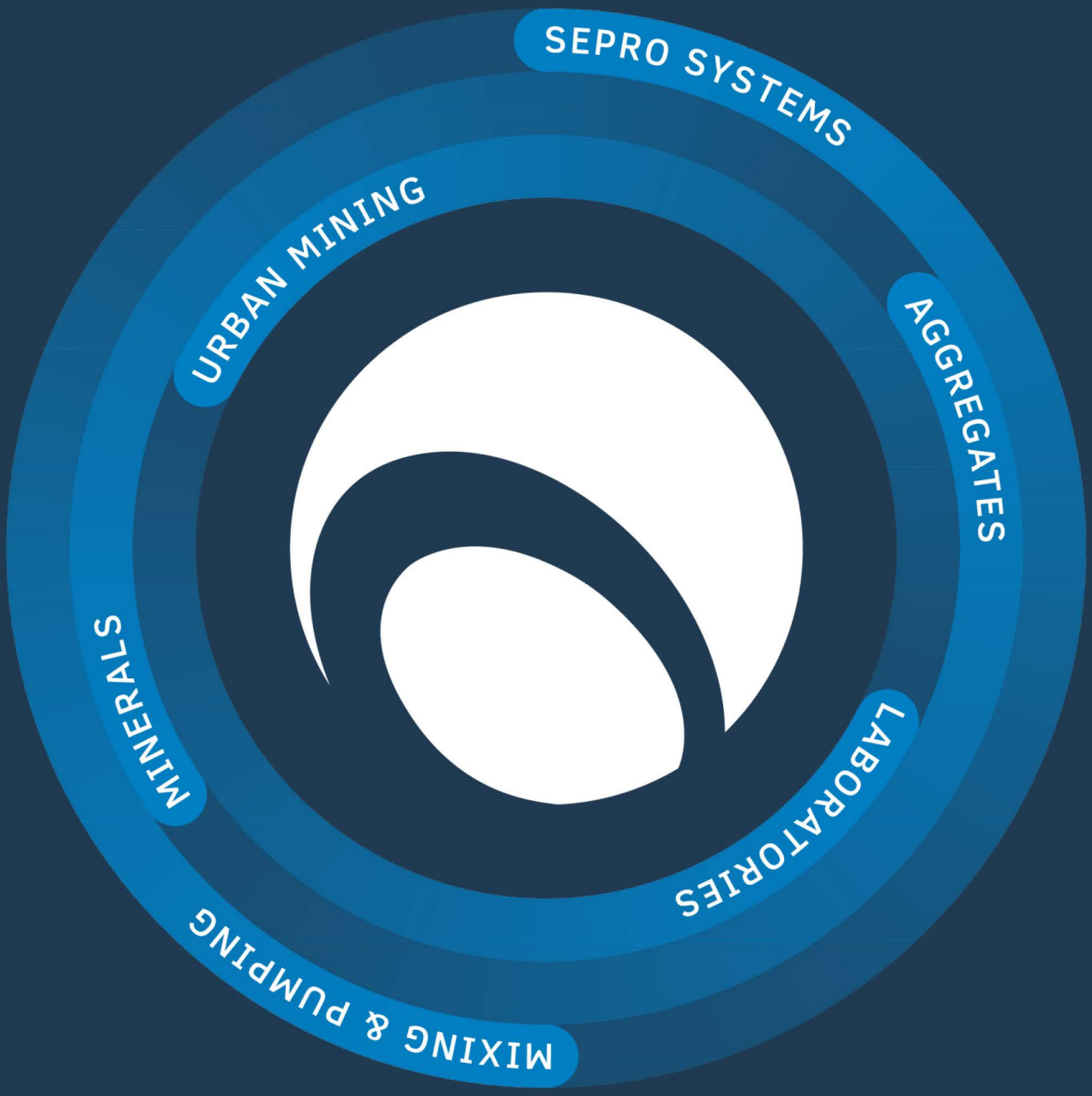
Summary

There are several reasons why gravity centrifuges have become an industry standard: with only a few moving parts they have a low cost of operation; consume a relatively low amount of power; only require water for effective particle recovery; are insensitive to large changes in feed; and can handle a wide range of particles sizes, typically from 0-2mm.

The Sepro Frontier™ bowl represents the first significant improvement in gravity gold recovery in more than 20 years, and we expect it will improve recoveries around the gold mining industry. Please contact Sepro Mineral Systems for more information.

About Sepro

Sepro Mineral Systems has been providing mineral processing equipment, technology and expertise to the mining industry for more than 30 years. Initially starting with cutting edge gravity separation technology, Sepro has expanded its expertise over the years to include a wide range of comminution and gravity separation processes, methods and technologies.



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