METSO OUTOTEC FLOWBOTTOM, FIRST REFERENCE EXPERIENCES AND LOOK BACK TO DEVELOPMENT

By

[1]Tuomas Hirsi, [2]Lauri Mäenpää, [3]Jari Peltola

[1]Metso Outotec Finland Oy, Finland
[2]Metso Outotec Finland Oy, Finland
[3]Metso Outotec Finland Oy, Finland

Presenter and Corresponding Author

Tuomas Hirsi
Tuomas.Hirsi@mogroup.com

ABSTRACT

Gold Cyanide Leaching agitators have been fairly standard for recent decades with only incremental changes. Good mixing is an important factor in gold cyanide leaching as the reaction kinetics are often controlled by mass transfer. In order for the leaching to proceed effectively, the solids should maximize the contact area with the solution, thus requiring complete solids suspension. This occurs when there is no solid settling nor solids bed formation at the bottom of the tank with all solids suspended. In optimal CIL configuration the agitation is optimized to achieve this solids suspension and required gas dispersion with lowest possible power consumption. Metso Outotec has developed new solution to optimize energy consumption and carbon attrition.

In first FlowBottom reference site Metso Outotec set out to solve a problem, where processing of high-grade gold concentrate resulted in recurring solids settling in the leaching tanks at the customer site. Inadequate suspension of solids lead to reduced capacity, more difficult adjustment of the slurry density and downtime of the tanks increased considerably.

Investigation of a solution started with authentic solids tested at research center at Pori, Finland and the tests confirmed the sanding issues with the existing agitation configuration providing reference point. An improved agitation solution was tested and tailored for the leaching tanks, which consisted of dual OKTOP®3300 impellers, FlowBottom element, and a SandSense measuring system for agitation optimization. The performance of this configuration was validated at the site and it was confirmed that the solution was able to completely suspend the solids without need for agitation power increase.

After more than 7 months of the upgrade with FlowBottom and SandSense, the tanks have not experienced downtime due to solids settling and utilization of their full effective volume has meant that the capacity of the tanks has increased up to 16%. In this work we will explain the functionality of FlowBottom, SandSense and achieved benefits in Svartliden and estimate what kind of further benefits it can provide in CIL process.

Keywords: CIL, CIP, OKTOP, FlowBottom, SandSense, Gold, Sanding, Solid suspension, Energy savings

INTRODUCTION

Agitators used in Gold Cyanide Leaching, in both CIL (Carbon in Leach) and CIP (Carbon in Pulp) reactors have been fairly standard for recent decades. There has been some incremental changes in the design of the agitators, mainly to bring down cost and improve the structural integrity of the agitators. However, the used mixing power (kW/m^3) and the generic layout of the agitators has been quite standard varying from 1 kW/m^3 in smaller CIL reactors to below 0.05 kW/m^3 in larger reactors. The reactor size normally varies between 10 to 15 meters of diameter, but smaller and larger reactors are also in use. A vertically operated agitator is generally used with a standard layout of two impellers. The diameter to height ratio with a tank is usually 1:1 or 1:1.1. Used impeller type is typically two-level hydrofoil agitator, where upper impeller might be upwards or downwards pumping. The Metso Outotec FlowBottom solution for more efficient CIL processing was developed and published first time in 2015. The FlowBottom is a bottom structure that enables mixing of CIL reactor with one impeller and considerably lower power requirement compared to conventional solutions. (1, 2).

The development of the FlowBottom was carried out with co-operation of CFD testing and laboratory testing. CFD modelling has also been shown outside of Metso Outotec research to provide good basis for development of CIL reactors agitation. The modelling and testing were to validate that FlowBottom can provide estimated solid suspension results, but also has no negative effect on the gas dispersion. Also, the effect of reduced power to carbon attrition was tested in laboratory environment. In Figure 1 it is shown the result of modelling tank operation with flat bottom tank and tank with FlowBottom(1, 2). In Figure 1 it can be seen significant flow rate increase and better suspension in FlowBottom than in flat bottom reactor in the same conditions.

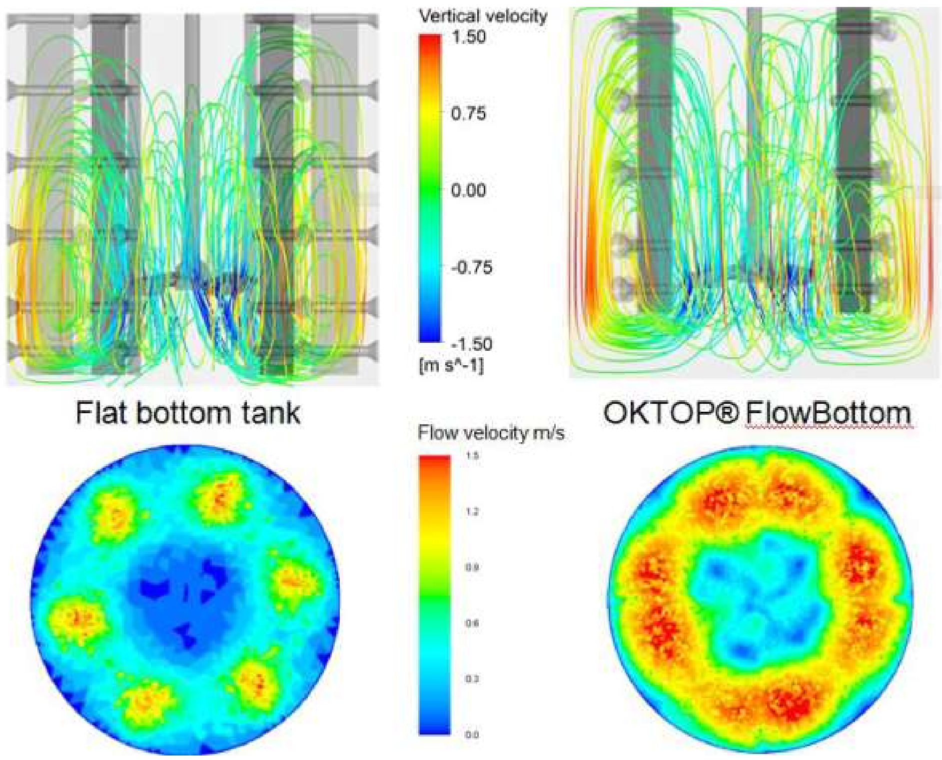

Figure 1. CFD comparison showing vertical fluid velocities and fluid velocities at 85 mm distance from the tank bottom with flat bottom and OKTOP® FlowBottom structures at the same impeller rotation speed. The cylindrical reactor has a diameter and solution surface height of 8.5 m and is agitated with an OKTOP®3200 hydrofoil impeller. (3)

SVARTLIDEN REFERENCE, PROBLEM DESCRIPTION

The leaching circuit in Svartliden plant is composed of two pcs of leaching reactors and five pcs of carbon in leach reactors. These tanks had been experiencing quite serious sanding issues with solid particles accumulating inside the tank. During longer periods of operation, the tanks required cleaning to remove solids accumulation on the bottom. This accumulation leads to loss of operational volume inside the tank and with measurements it was estimated that 16% of the volume of each tank was lost due this issue. Sanding indicates that the agitation inside the tanks is insufficient.

Good mixing in the CIL reactor is essential to provide efficient mass transfer, gas dispersion and oxygen utilization, but to also provide good flow from one reactor to other. In the CIL reactor solids are transferred through intermediate screens that reside at the top section of the tank. If the solid suspension level in the tank is not uniform, larger particles do not rise to the top of the tank and are not transferred to the next reactor. This will cause in long run sanding on the reactor and process problems.

This problem could have been solved with replacing agitators with more power to ensure solids suspension and adequate mixing. However, increase in the motor power was not allowed due to the structural limitations set by the current agitator support structure and tank. This required other solution to be found for the problem.

PROPOSED METSO OUTOTEC SOLUTION

To solve the problem Metso Outotec proposed use of Metso Outotec FlowBottom. This novel new technology did not have any existing references but had been thoroughly tested in our research center in various scales. In this case the benefit of the FlowBottom is that it does not need any additional mixing power but can provide big increase on the solid suspension properties of the agitation.

Laboratory testing of the proposed solution for Svartliden was carried out in the Pori Research Center in Finland. The testing was done with actual material from the site and included solid suspension testing with current agitation in the laboratory scale as well as with FlowBottom solution in the laboratory scale. In addition to the solid suspension test the effect on the carbon attrition was tested. The proposed solution was also calculated with CFD model (Figure 2) to see how the mixing would perform in the industrial case. The final results of testing were that in full suspension conditions the FlowBottom could lead to 65.3% reduction in power consumption and 60.3% reduction in carbon attrition taken place in CIL reactor.

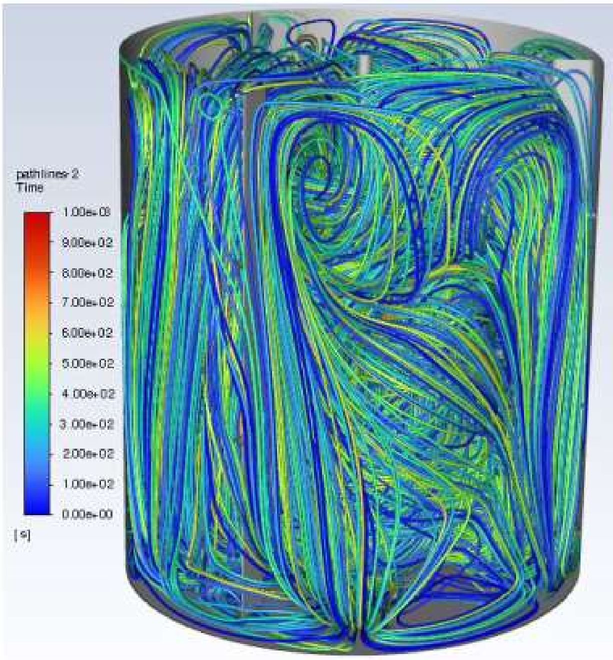

Figure 2. Flow path lines in the reactor with CFD modelling and FlowBottom in place.

The final selected agitation is combination of 2 pcs of Metso Outotec OKTOP 3300 impellers with FlowBottom. Due this being the first reference for Metso Outotec FlowBottom, and the above 1:1.1 aspect ratio, it was decided that 1 impeller to not be used here and 2 impeller levels was utilized.

PROVING THE SOLUTION

Testing campaign

The important factors to be tested during the test campaign were:

- Complete solids suspension with no sanding occurring.
- Uniform suspension of the particles so that there is no difference in solids % or particle size distribution in different heights on the tank.
- Electrical consumption of the agitator when flow bottom is used.

The testing campaign on the site was performed in co-operation with the Svartliden mine personnel. The testing campaign lasted for one year with the main target of proving that FlowBottom works in varying conditions on site during long operational period. In addition to the operational testing there were 2 visits from personnel of Metso Outotec Research center from Pori. During these visits more focused testing on the product development was done.

Temperature measurements

During the operation of the sanded tanks the site personnel noticed it was very straightforward to measure the sanding inside the tanks by measuring the temperature of the wall with handheld IR-camera. This showed quite clearly where the solid bed started inside the tank.

When a solid bed forms at the bottom of the reactor it can act as a thermal insulator compared to freely moving slurry for which convective heat transfer can distribute the heat much more efficiently. Outside the tank this can be seen as a higher wall temperature at sections where the slurry can move.

Figure 3 shows the measured wall temperature profiles before and after the agitator upgrade. A clear transition can be noticed in the prior upgrade-profile at approximate height of 1.4 m from the bottom. This level gives a good indicator of the solid bed height near the wall. On the other hand, the profile after the upgrade shows only a minor fluctuation around average temperature, which is a sign of effective heat transfer even at the bottom of tank, and therefore absence of a settled bed.

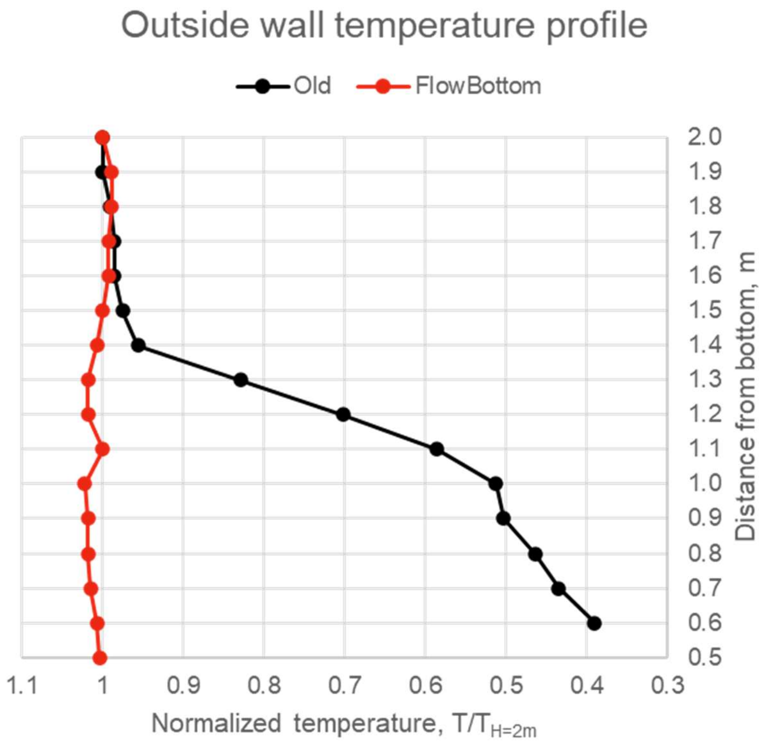

Figure 3. Normalized temperature (T/TH=2 m) with respect to measurement height.

According to the experience of the site personnel, the settled bed takes a "bowl"-shaped form due to the flow pattern created by the agitator. Considering this shape and the height of the bed near the wall, an estimate for the volume occupied by the bed can be calculated. Assuming the height of bed at the center to be about half of the height at the wall, the volume of this disc with a concave side is approximately 16% of the effective volume of the reactor. (Figure 4).

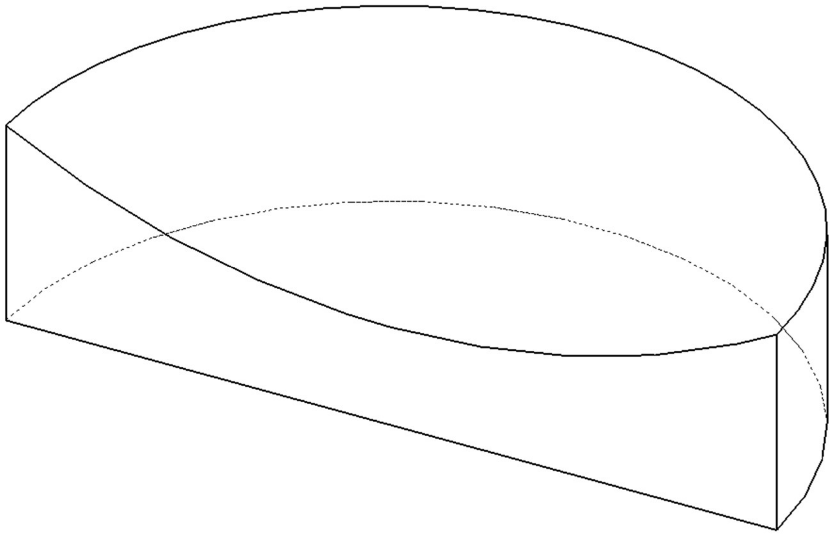

Figure 4. Illustration of the solid bed inside the tank.

SandSense

The operation was continuously followed by Metso Outotec SandSense instrument. This instrument is a proprietary industrial scale method to follow solids accumulation on the bottom of the tank in real time and is located on the side of the tank which has been shown in laboratory test to be first place to sand in both conventional and FlowBottom agitation. SandSense instrument is based on electrical resistance measurement. SandSense can measure up to 1 meter from the bottom of the tank with high accuracy.

There was no sand bed accumulated during normal run with agitator speed from 50% to 100%. To ensure the reliability of the instrument, a “stop-and-go" test was carried out. The agitator was stopped and settling was allowed to occur. This was detected by SandSense as the reading increased slowly when particles accumulated to the bottom of the reactor (Figure 5). The disappearance of the bed was also clearly visible in the trend when the agitation was restarted. Between the solid bed and the liquid there was a clear difference in conductivity in which the measurement is based on. The SandSenses were equipped with remote connection possibility and commissioning & testing was done on remote mode with live process operation, illustrating the flexibility and repeatability of this testing method. (4)

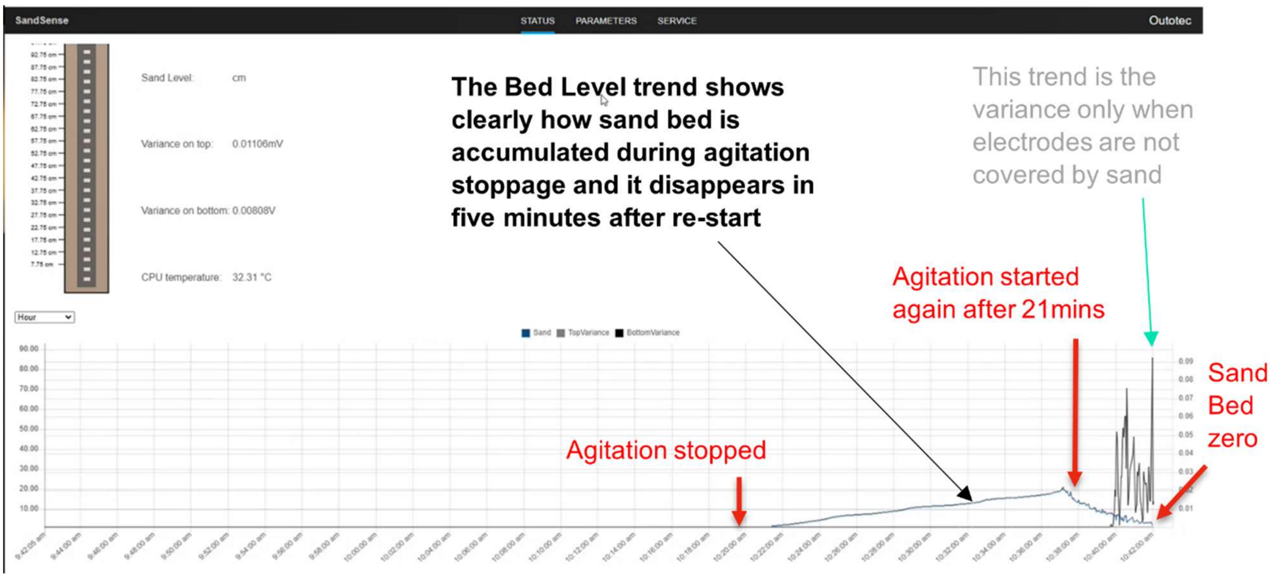

Figure 5. M The trend covering a “stop-and-go" test. View from the SandSense Status page.

Particle size tests

During the trial period, the uniformity of the solid distribution was tested by collecting slurry samples at different depths of the reactor. This was particularly important for prolonging the operating time as the slurry outflow was via overflow and necessitated that also the coarse particles should reach the outlet.

The samples were collected with a dip sampler that allowed the slurry samples to be collected at different depths. The device consists of a spring-loaded cap for the container, which can be opened by pulling the string attached to the cap. With the help of extension pipes the sampler can be guided to the desired depth and operated from the top of the tank. Photos of the device are shown in Figure 6. After collecting the samples, the slurry was filtrated and washed and shipped to Pori research center, where the particle size distribution was determined by laser diffraction method.

Figure 6. Dip sampler used for the sample collection.

Results of the particle size analyses are shown in Figure 7. As seen from the figure the trends are almost horizontal, meaning that there is little difference between the samples at different depths. This was an important finding, especially for the coarsest fraction as it meant that no accumulation was expected even after a longer operation time. The results of high degree slurry uniformity were also supported by the fact that the plant was able to operate the reactors without any mixing related issues for the entire trial period.

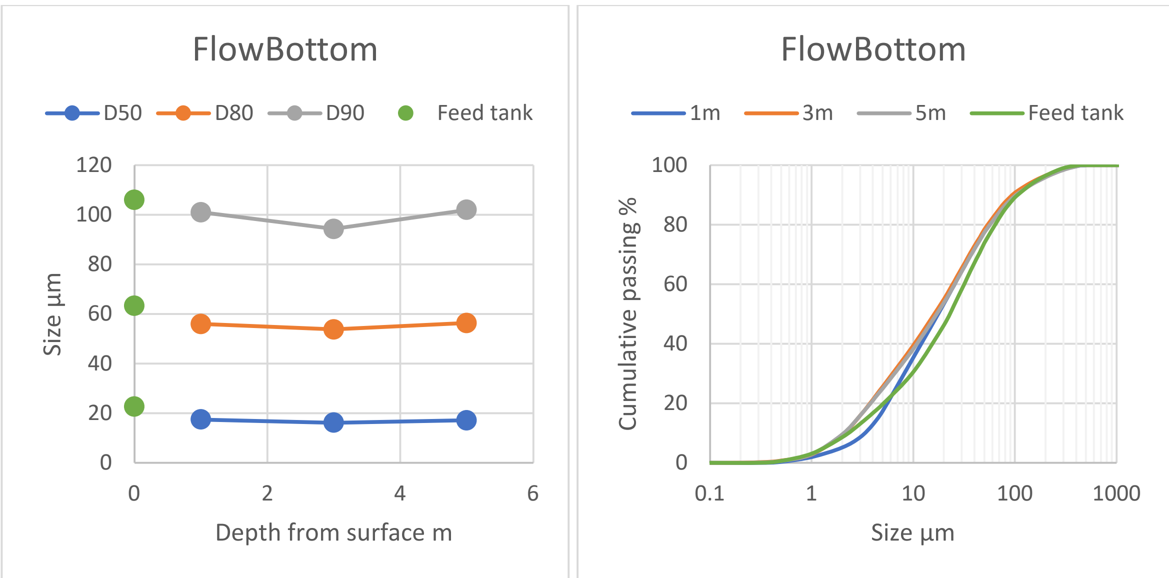

Figure 7. PSD results for the upgraded reactor. The feed tank sample was collected from an upstream tank to provide a reference for the solids.

Electrical consumption

Total electrical consumption was observed from the frequency converter on site when operating the equipment. From this it is possible to further calculate by taking in accordance the electrical losses what is the absorbed power of the agitator when utilizing it with FlowBottom and whether there are differences to the scaled-up laboratory values. Testing of the electrical consumption was done with multiple different rotational speeds to check the whole operational range of the agitator.

Agreement with the laboratory values was on a good level and supported the finding that the upgraded agitator would run at a lower power draw compared to old installation. After the electricity consumption tests, the agitation was adjusted to adequate levels of agitation ensuring solid suspension and good surface movement. This agitation rate was later confirmed with PSD samples (see previous chapter) to provide near uniform solids distribution. With the mixing speed confirmed the longer testing period started, during which agitation rate was kept nearly constant.

At time of testing the power consumption resulted approximately to 29.9% power reduction compared to the original. Considering the upgraded agitation system was able to resolve the heavy sanding issue and still reduce the electricity consumption that highlights the impact of FlowBottom. Annually, this means a power saving of approximately 21 MWh, which also corresponds to a reduction of CO_2 in the range of 4.2-8.4 t/year (200-400 kg/MWh) depending on the energy source, if the electricity is produced with fossil fuels. (6)

Further work

The benefits of lowering the mixing power are not limited to electricity consumption. Reduction of energy input also has a positive impact on the reduction of carbon attrition in the adsorption tanks. This in turn can provide additional savings from reduced carbon consumption, and more importantly gold losses via carbon fines.

Gold losses due to carbon attrition happen when carbon particles, loaded with gold, are broken into a smaller size than the interstage screen size allowing them to pass to the tailings. Carbon fines also have a high specific surface area making them efficient in adsorbing and increasing their gold content. The savings potential for gold loss reduction can be a significant part for the total savings in agitation optimization. Focusing on minimizing the losses at the final stages of the recovery also means the efforts for extracting the gold in previous processing stages are not wasted. (3, 5)

Proving reduction of carbon attrition with lower mixing energy is straight forward in batch tests at laboratory scale. However, quantification of carbon attrition reduction is very difficult in a continuous large-scale process, as it requires very stable operating conditions on long testing periods and is not only affected by the mixing at the adsorption circuit. The reduced mixing intensity also brings benefits to maintenance. Lower energy utilized for agitation leads to less wear on the agitators and longer operation time. This can be considerably saving in cases were feed material has high wear properties. Maintenance benefits can only be observed over longer time and will be a purpose of further work.

CONCLUSIONS

Site validation tests, as well as the smoothly went long trial period, confirmed the successful agitator upgrade. The main problem of sanding was resolved with a tailored mixing solution that provided also near-uniform slurry homogeneity at reduced power draw. The disappearance of the settled bed meant that the reactor could utilize its full capacity, increasing the effective volume up to 16% and reducing the operational downtime. The increase of the effective volume compared to the old installation effectively means the increased volume is one extra tank compared to the old installation and this will lead to improved gold recovery.

Testing was performed with multiple methods to ensure that all the aspects of required agitation were taken in consideration. SandSense was working as designed and it was tested for both – LT1 & LT 2 – reactors with good results and further illustrates the benefit of using SandSense instrument in optimizing and monitoring process performance.

Now that the solid suspension performance of the FlowBottom has been proven further work is still required to show the additional benefits. The savings on operational costs via decreased gold and carbon losses and reduced maintenance needs can bring even further benefits. This work will continue further as more operational time with FlowBottom is accrued.

ACKNOWLEDGMENTS

Metso Outotec would like to thank you Dragon Mining staff and management for excellent co-operation during the testing campaign and important insights to the analyze of the results and functionality of the equipment.

REFERENCES

1. Latva-Kokko, M, Hirsi, T., Ritasalo, T. & Tiihonen, J. (2015), Improving the process performance of gold cyanide
leaching reactors, World Gold Conference 2015 – Proceedings, The Southern African Institute of Mining
and Metallurgy, pp. 183-193

2. Divyamaan Wadnerkar, Vishnu K. Pareek and Ranjeet P. Utikar, CFD Modelling of Flow and Solids Distribution in Carbon-in-Leach Tank, Metals Journal 2015

3. M. Latva-Kokko, J. Kourunen and K. Lillkung, New Ways To Reduce Carbon-Related Gold Losses In Cil And Cip Processes, Worl Gold 2017.

4. Kourunen, J. (2014), Imaging of mixing in selected industrial processes using electrical resistance tomography, Academic Dissertation

5. M. Latva-Kokko, J. Kourunen and K. Lillkung, (2017), New ways to reduce carbon-related gold losses in CIL and CIP processes, COM2017 | The conference of metallurgist hosting World Gold & Nickel Cobalt

6. Carbon dioxide emissions factor (ourworldindata.org) https://ourworldindata.org/grapher/carbon-dioxide-emissions-factor, accessed 24.03.2023.