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# Optimizing Froth Zone in Larger Flotation Cells Through Innovative Spider Crowder Upgrade

**G. Bermudez**
Metso Canada, Burlington, ON, Canada

**A. Jalili**
Metso Canada, Burlington, ON, Canada

**C. Cardoso**
Metso Chile, Santiago, Chile

**ABSTRACT**
Bigger flotation cells can result in larger froth surface areas and longer froth transport distances, this has been credited to impact froth recovery. Thanks to recent advancements, the newer flotation machines can be designed with different launder and crowder arrangements to enhance froth management. Nevertheless, lower head grades, complex ores and even larger mechanical flotation cells can lead to insufficient froth collection, even if the cell is equipped with the most recent flotation advancements like the center launder design. Aforementioned issue can become critical at the end of the flotation row. Increased crowding has been proven to be a solution to overcome inadequate froth recovery. However, scaling-up crowders for larger flotation cells can rise challenges, particularly in terms of structural limits and design for service. This paper presents the development journey for the Spider Crowder Upgrade, an advancement to improve froth collection in large flotation cells that are already equipped with center launders.

## INTRODUCTION

Flotation is key mining operation to separate valuable materials from gangue to facilitate obtention of necessary metals that are highly demanded for current global needs, such as electrification and manufacturing. Consequently, this has surged the growth of concentrator plants to fulfill the aforementioned. This trend can be noticed at the flotation circuits, where cells have increased to volumes larger than 600 $m^3$.

Some benefits that these larger flotation machines have brough include the possibility to process higher throughputs, reduced installed footprint and energy consumption optimization. Nevertheless, they also have resulted in new challenges, like the need for newer maintenance strategies and difficult froth management.

Bigger cells have reported poor froth collection and low coarse particles recovery, thus hampering metallurgical performance. This effect has been attributed to its legacy design including suboptimal froth zone parameters, like large froth surface area and long transport distance.

Froth zone parameters relative to flotation tank volume growth has been plotted by Corona et al. (2021) in Figure 1 for Metso´s flotation cells installations. As detailed in the graph, there is a correlation between cell´s volume and froth transport parameters, such as Froth Surface Area (FSA), Froth Transport Distance (FTD) and Lip Length (LL). When these factors grew significantly, different arrangements of launder and crowders were trailed to mitigate this effect.

According to Mesa and Brito-Parada (Mesa and Brito-Parada, 2019b) it is highlighted that the available literature on the design of different inserts for froth control

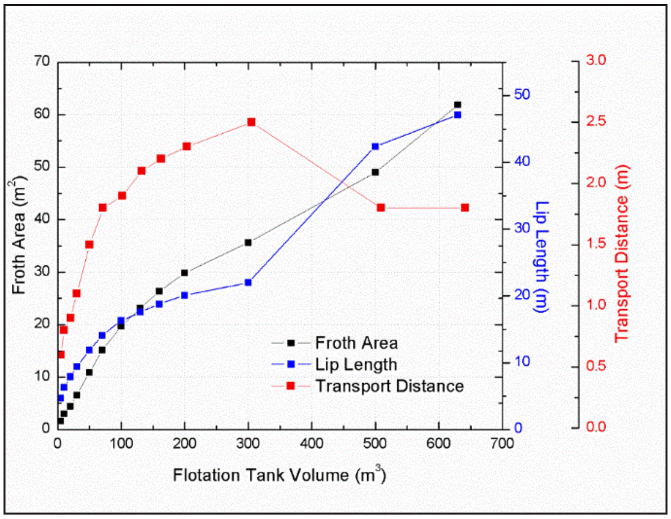


**Figure 1. Froth transport parameters relative to flotation cell volume**

and transport, such as launders and crowder are rare. Therefore, a fundamental understanding of the effect of froth crowders and launders on flotation performance is essential to a scale up process from flotation lab tests. This difficulty of not being able to scale up is due to the froth being scraped off during a flotation test in the laboratory and, therefore, does not exhibit a natural behavior, and it is not possible to increase the transport distance of the froth (Coleman, 2009).

These days there are several industrial launder and crowder designs that are used particularly in large volume cells to improve froth management (Figure 6). Their characteristics will be defined during the design and engineering phase of a green field project. When it comes to brownfields, the correct froth management gear needs to be carefully selected not only in terms of metallurgical performance but also in terms of flexibility to be installed through retrofits. Table 1 summarizes three different projects where metallurgical improvement was achieved through launder retrofits in Cu-Mo rougher-scavenger circuits:

Concisely, Center launder upgrades have been a successful way to improve metallurgical performance in large flotation cells with low froth collection, the retrofit effect can be maximized if process optimization is undertaken following the upgrade. Nonetheless, crowding via center launder has its own limitation, and currently there are not many options for a given large flotation cell with low froth recovery that was originally equipped or recently retrofitted with center launders. Process optimization might be a way, but it can only handle as far as the limitations of the existing assets. (Bermudez et al, 2021). A potential solution for flotation cells with too low froth carrying rate was introduced by Outotec SEAP (now Metso Australia) named "Radial froth crowders" or "drop-in crowders." These were proposed to be installed on top of peripheral and center launders to increase crowding. Figure 3 details the solution (Morgan, 2018). However, these crowders were not properly scaled-up for flotation cells larger than 200 m$^3$. Some challenges to use this solution for cells with the volume of 300 m$^3$ or larger include: Adding more crowding closer to the tank perimeter where comprise larger section of FSA in

**Table 1. Summary of launder retrofit projects, in descending order: Bermudez et al (2021), Bermudez et al (2022), Weiping Liu et al (2022) and D. R. Seaman et al (2022)**

| Plant | Country | Flotation Machines | Launder Retrofit |
|---|---|---|---|
| Hudbay Constancia | Peru | 3 × 300 m$^3$ cells | Center Launder |
| Rio Tinto KUCC | USA | 3 × 300 m$^3$ cells | Center Launder |
| FMI Bagdad | USA | 3 × 300 m$^3$ cells | Center Launder |
| NewCrest Red Chris | Canada | 6 × 200 m$^3$ cells | Center Launder |

**Figure 2. Photo comparison between both launder configurations, radial launders (left) and center launder (right) in Kennecott (2022**

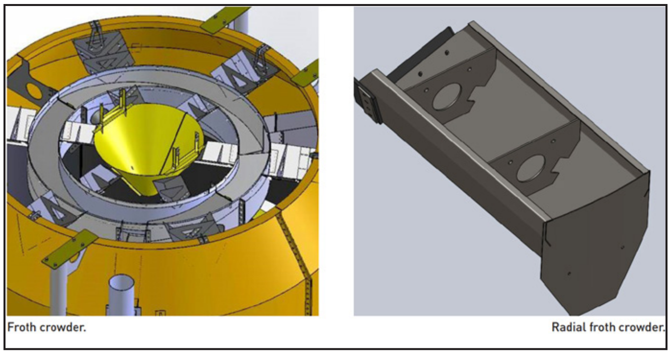


**Figure 3. Radial froth crowders introduced in Australia, assembly (left) and individual (right)**

order to prevent stagnant froth in that area, avoiding design of too large crowder plate size to prevent pulping effect on the froth surface, and designing strong crowder structure with optimized weight to ensure overall load on the tank does not exceed design criteria.

## SPIDER CROWDER UPGRADE JOURNEY

Metso was contacted by a Copper operation looking to improve froth collection in colossal flotation cells, particularly at the end of the circuit, The Spider Crowder Upgrade is the result of engineering to adapt drop-in crowders for TC630 cells. The challenging criteria instituted for developing a successful solution included: crowding more to tank perimeter as froth surface area concentrically grows towards the edges of the tank, avoiding too large crowder plate sizes to prevent boiling effect on the froth surface, strong structure with optimized weight to ensure overall load on the tank does not exceed design criteria, easy installation with no/minimum modifications to the cell, and having future service in mind and allowing easy access into the tank for exchange of mixing mechanism wear parts

Through a comprehensive R&D project the Spider Crowder design was developed that successfully met all the criteria mentioned above. The new crowder included:

- Novel crowder design with complex shape for the outer area of the center launder. This nonsymmetric shape provides more crowding at the tank perimeter and less close to the center launder. This resulted in two different types of spider crowders to cover the inner and the outer surface of the froth zone.
- Innovative hanger systems to minimize installation time of the crowders and facilitating easy removal of them to provide access for maintenance.

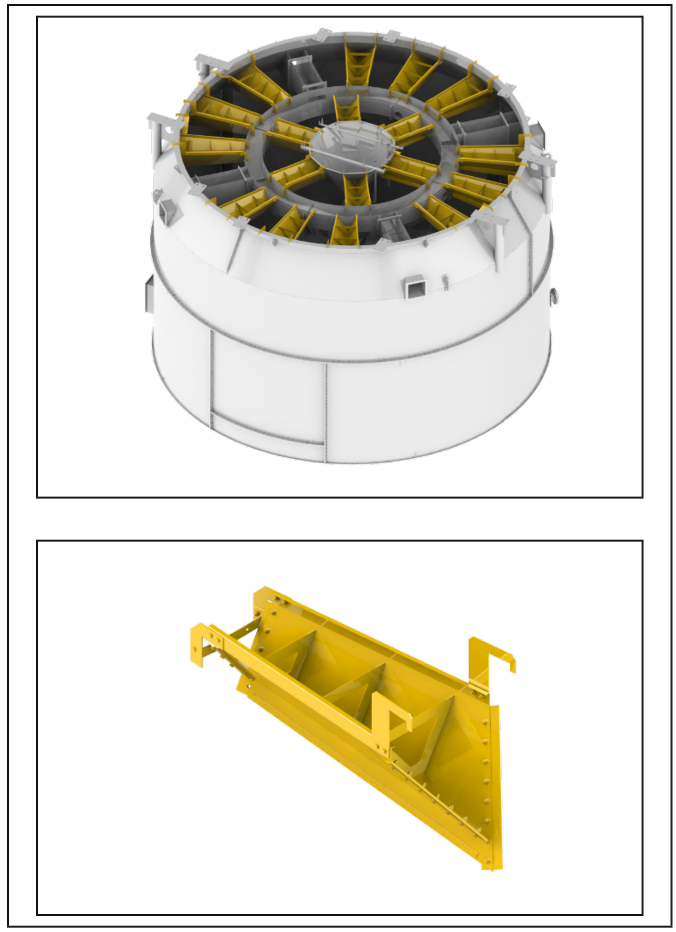

**Figure 4. Spider Crowder assembly (top) and outer spider crowder insert (bottom)**

## SPIDER CROWDER INSTALLATION

The installation of the Spider Crowder Upgrade took place in early 2023. The installation was designated for penultimate cell of one rougher line. The scope of supply consisted in 18 Crowders, 6 to be installed in the inner froth zone and 12 in the outer froth zone.

The retrofit was executed during a planned plant´s shut down. It was concluded without any safety concerns and within the estimated mounting time of 24 hours.

The spider crowder impact on the froth zone parameters is described in Table 2. As detailed, the new Spider Crowders decreased upgraded cell´s FSA by 21.2 m$^2$. This results in a crowding increase from 34.5% to 56.6%. The lip length was decreased by 14.3 m; this is mainly due to spider crowder being dropped on the center launder and consuming sections of center launder lips where it is hanged on.

**Table 2. Froth Zone parameters before and after Spider Crowder Upgrade**

| Cell TC630 | Original Condition with Center Launder | Upgraded Condition with Spider Crowder |
|---|---|---|
| FSA ($m^2$) | 62.2 | 41.2 |
| LL (m) | 34.6 | 20.3 |
| Crowding | 34.50% | 56.60% |

**Figure 5. Internal view of Spider Crowder Upgrade in cell 7 of Line 1**

## SPIDER CROWDER EFFECT IN PROCESS PERFORMANCE

Two different sampling campaigns (before and after the retrofit) were carried out to evaluate the effect of the spider crowder in process performance. Both campaigns were performed around the upgraded cell, individually, looking for evaluating the process performance after the installation of the system. Each sampling campaign was carried out utilizing two manual samplers: a diaphragm pump sampler and a lip sampler. Timed sampling was performed with the lip sampler to be able to collect the concentrate froth directly from the flotation cell overflow, while the pump was used to sample the feed and tails of cell 7. The feed from cell 7 was collected from the tails of cell 6.

Four sampling rounds were carried out in each campaign. Accounting for the solids concentration of each concentrate sample, the lip length of the lip sampler and cell's total lip length, the mass pull is obtained (through timed sampling with the lip sampler). The feed, concentrate and tails samples obtained were process at site.

Mass Pull in the upgraded cell obtained from the sampling campaigns were, on average, 13.9 t/h for the first campaign (before) and 17.8 t/h for the second (after). The above indicates a 28% mass pull increase, after the installation of the Spider Crowder system. Also, based on the indicated results, an increase in the Froth Carry Rate (FCR) can be observed, on average, from 0.49 $t/m^2h$ to 0.86 $t/m^2h$, which results in a 75% improvement after the installation of the retrofit.

## SPIDER CROWDER EFFECT IN THE OPERATIONAL PARAMETERS

Operational parameters 12-hours average were analyzed, this included air flowrate and froth depths for studied cell during the period between January 1st 2023 to June 10th 2023. Trend analysis over time for airflow rate and froth bed is shown in Figure 6.

Average values for the periods before and after the retrofits are detailed in Table 3. It is noticeable from Figure 6 and Table 3 the change on the operational parameters during the evaluation period. Airflow rate decreased by 16% while froth bed increased by 17%.

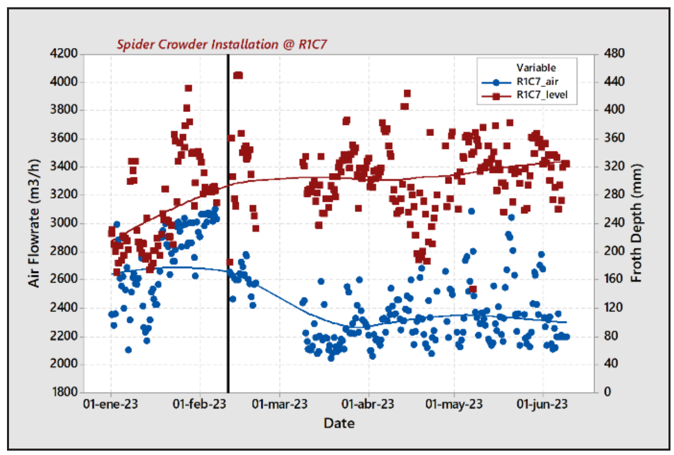


**Figure 6. Time Series Plot for cell 7 in rougher line 1 including air flowrate ($Am^3/h$) and froth dept (mm)**

**Table 3. Average operational parameters values during evaluation period**

| Cell | Period | Airflow rate ($m^3/h$) | Froth bed (mm) |
|---|---|---|---|
| TC630 | Before upgrade | 2731 | 266.3 |
| TC630 | After upgrade | 2353 | 311.7 |

## CONCLUSIONS

A froth crowding solution named Spider Crowder Upgrade was developed by Metso to improve froth collection in a Copper operation with large flotation cells already equipped with center launders. This is a scale-up advancement from legacy Australian radial crowders. The upgrade was implemented in the seventh cell of on a rougher line during the first quarter of 2023. The process assessment for this development included single sampling campaign for the period before and the period after, it also comprised operational parameters evaluation during the trial period. The Spider Crowder Upgrade resulted in:

1. Crowding increase in the froth zone from 34.5% to 56.6%.
2. Increase in mass pull from 13.9 tph to 17.5 tph. This relates to an increase in froth carrying rate from 0.49 t/m$^2$h to 0.86 t/m$^2$h.
3. Decrease in airflow rate from 2731 m$^3$/h to 2353 m$^3$/h, resulting in 16% reduction.
4. Increase in froth depth from 266.3 mm to 311.7 mm, resulting in 17% rise.

Although this Spider Crowder upgrade was developed and tested in 630 m$^3$ cell, but it can also be used in 300 m$^3$ or smaller cells that already have Center Launder but still require more crowding.

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24-068

# Ore Control Technological Innovations at Peña Colorada Mine

**M. Marín-Pasillas**
Peña Colorada, Colima, México

**H.R. Hernandez-Guerrero**
Peña Colorada, Colima, México

**S. A. Robles-Salazar**
Hexagon Mining, México

**P. J. Pompilla-Rosales**
Hexagon Mining, Perú

## INTRODUCTION

Peña Colorada is a company dedicated to the exploration, exploitation, and beneficiation of iron ore, serving the national steel industry. Established in 1975 as a state-owned enterprise, it transitioned to operating as a private organization in 1991. It is jointly owned by two investors, ArcelorMittal and Ternium, each holding a 50% stake. The mining operation is situated in the municipality of Minatitlan, in the northwestern part of the state of Colima, Mexico (Figure 1).

It comprises an open pit mine and a concentrator, covering an area of approximately 2,300 hectares. The pellet mill is in the town of Manzanillo, Colima state, a port on the Pacific coast, about 46 km southwest of the mine. The pellet mill occupies its own property with a total area of 60.4 hectares. A gravity-driven concentrated slurry pipeline connects the mine and the pelletizing plant, located at an average elevation of 1,020 meters above sea level and 20 meters above sea level, respectively. Currently, Peña Colorada produces 4.1 million tons of pellets and 0.4 million tons of iron concentrate annually.

In 2018, due to a change in the cutoff grade, the processing volume of the beneficiation plant increased from 9 million tons to 16 million tons annually. This led to a greater amount of information to process and characterize the ore extracted from the pit before its processing in the beneficiation plant. Consequently, Peña Colorada sought new ore control technologies to enhance ore selection, optimize human resources and data management, as well as minimize discrepancies between planning and execution. To ensure adherence to quality agreements with stakeholders, it is crucial to understand the ore characteristics before initiating mining activities.

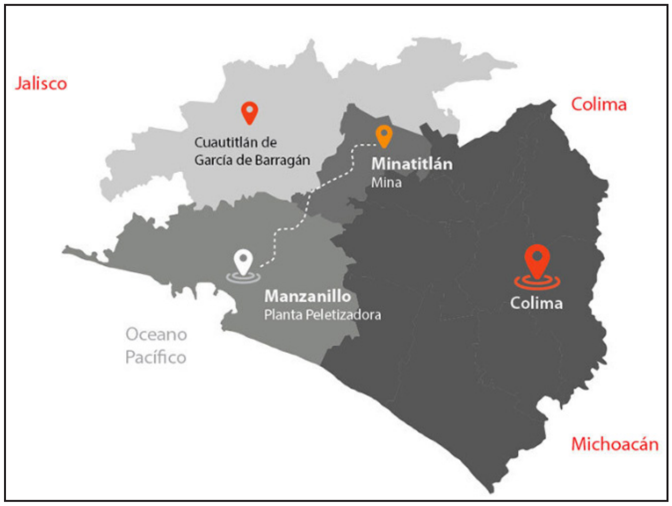


**Figure 1. Project location**

## PROJECT OVERVIEW

In mining, operations engineers and geologists process extensive data to extract valuable information from the field. Their role is to transform this data into actionable knowledge, guiding crucial decisions for mining execution and production monitoring. Efficient communication tools are vital for conveying these decisions to stakeholders. This document explores how the adoption of a new Ore Control (OC) technology addresses these challenges, enhancing selectivity, performance, and data management while minimizing planning-to-execution variation. OC technology drives comprehensive operational improvement.