Reflections on 25 years of SWIRLFLOW® Operation at QAL Alumina Refinery

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Abstract

In the early 1990's, QAL started looking for an alternate agitation technology for precipitation tanks that was high efficiency, low cost and scale growth inhibiting, seeking to replace the existing draft tube agitators. A partnership between QAL and CSIRO resulted in the joint development of SWIRLFLOW®, a slurry mixing technology that reduces sedimentation and scale formation in alumina precipitation tanks, thereby improving tank productivity.

QAL plant trials commenced in 1997 and were supported by modelling tasks undertaken by CSIRO. The initial version of SWIRLFLOW® was only suitable for precipitation tanks with conical bottoms. However, ongoing R&D that included numerous plant trials at QAL has established that running a backswept impeller is significantly more efficient than the original design. Furthermore, laboratory and plant trial results showed that a larger impeller-to-tank diameter ratio could reduce power consumption, allowing SWIRLFLOW® to operate in fillet-flat bottom tanks at QAL.

Compared to draft tubes, QAL has found that precipitator tanks utilizing SWIRLFLOW® technology typically have thinner scale deposits on tank walls, achieve increased operating factor, and are much easier to restart. All these factors lead to operational and maintenance cost savings. Based on laboratory studies and other plant implementations, it is possible to further optimize SWIRLFLOW® to consume lower power and to operate with higher solids concentrations than presently achievable.

At the time of writing, SWIRLFLOW® has been retrofitted to 30 of 106 precipitation tanks at the QAL refinery, with more conversions planned.

Keywords: SWIRLFLOW®, Precipitation, Impeller, Draft tube

1. Introduction

With a focus on improving precipitation tank efficiency, QAL initiated a partnership with CSIRO in the early 1990s to develop SWIRLFLOW®, an innovative slurry mixing technology. This paper explores the transformative journey of SWIRLFLOW® over the past 25 years, detailing its evolution, applications, and impact on QAL's alumina refining processes.

The primary aims of the SWIRLFLOW® design were to reduce scale growth over the tank wall by the cleansing effect of the swirling motion produced, while also increasing overall reliability by simplifying the mechanical structures in place.

The original SWIRLFLOW® was designed specifically for conical bottom tanks. It creates a tornado-like swirling flow pattern as shown Figure 1 (a), resembling that occurring in the natural environment. The flow is generated by an impeller located in the upper part of an unbaffled tank. The SWIRLFLOW® generates strong upward velocity in the centre of the tank, which then picks up solids from the bottom of the tank and carries them to the upper regions. Upon impact with the SWIRLFLOW® impeller, the slurry is dispersed to the outer region of tank where the solids continue to spiral downward along the tank wall en-route back to the base, to be lifted again During this process, mixing and dispersion occurs. Figure 1 (b) shows a SWIRLFLOW® installation at QAL.

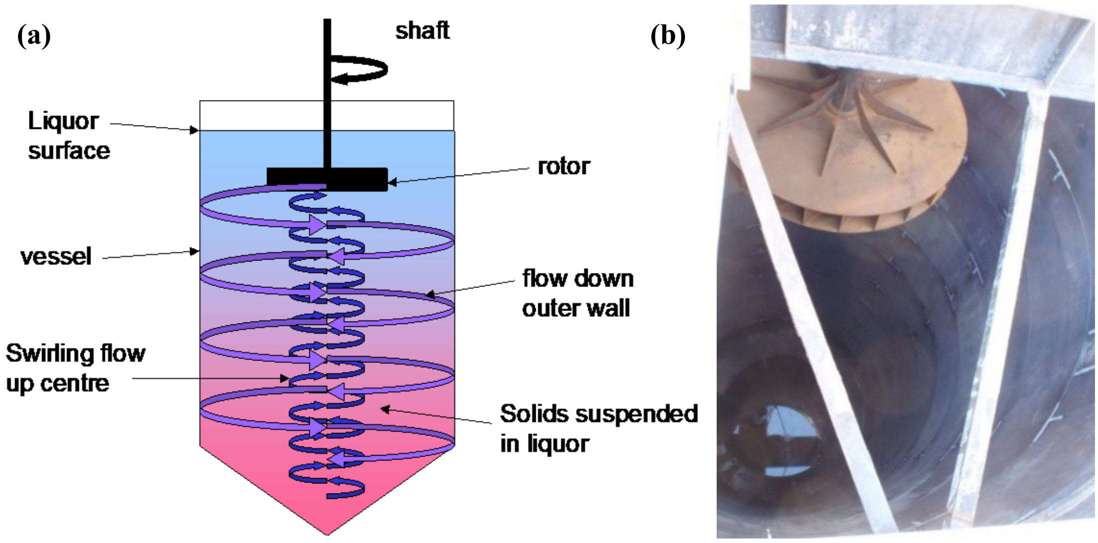

Figure 1. Swirl Flow, (a) concept, (b) in a QAL precipitation tank.

1.1 SWIRLFLOW® Development Phase

During the development phase of SWIRLFLOW® for QAL's precipitation tanks in 1997, the CSIRO Thermal and Fluid Dynamics team utilised their physical modelling and computational fluid dynamics (CFD) capabilities to gain better understanding of the existing draft tube design for comparison with the SWIRLFLOW® option. Modelling accounted for QAL's operating conditions and slurry characteristics at that time. A geometrically scaled-down QAL precipitation test rig for physical modelling was set up in the laboratory in Highett, Melbourne, as shown in Figure 2, with (a) the existing design (draft tube) and (b) SWIRLFLOW®. The developed SWIRLFLOW® was then benchmarked against the draft tube performance, focusing on the wall velocity and solids suspension, both critical parameters towards minimising scale growth on the tank wall and keeping the tank bottom free from sedimentation. Simultaneously, CFD simulations were conducted using CFX software, as shown in Figure 2 (c).

being exposed to the air at a higher turnover rate, assisting evaporation, radiation and convection from the top of the tank.

4. Discussion

Results from physical and CFD modelling show that SWIRLFLOW® mixing performance is more efficient compared to the draft tube arrangement. However, power savings have not been a factor in considering the design, as it was always intended to keep the motor used with the existing draft tube. This suggests that there is potential to further optimise power consumption.

While the modelling work was conducted thoroughly, the implementation stage is the most crucial aspect of any technology rollout. There have been instances where the trial results did not align with the modelling results, or where a second trial failed to replicate the results of a first. This discrepancy may have been due to the conditions of the tank that QAL was operating at the time. QAL believes it vital to regularly update and align the modelling team with the plant results. That SWIRLFLOW® technology has been successfully implemented in many QAL precipitation tanks was thanks to the hard work and close collaboration between the technical team at the plant and the technical modelling team at CSIRO.

5. Conclusion

In less than three decades, SWIRLFLOW® has transformed alumina precipitation tank operation at QAL, reducing maintenance costs, reducing scale deposits, increasing online cycle times, and facilitating easier restarts. Continuous R&D efforts, coupled with plant trials, have led to advances in impeller design and increased efficiency. As of the paper's writing, SWIRLFLOW® has been retrofitted to 30 of 106 precipitation tanks at the QAL refinery, with positive results. The technology's impact on productivity, cost savings, and safety underscores its significance in the alumina refining industry.

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7. References

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