Successful Application and Installation of SWIRLFLOW® Mixing Technology in an Inverted Cone Precipitation Tank at the Hindalco Alumina Refinery in India

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Abstract

Precipitation is a critical process in the white side of alumina refineries where nucleation and crystallization occur to form alumina hydrate product. The precipitation process utilizes a series of precipitation tanks connected via launders or pipes which allow continuous flow for providing the required residence time and temperature profile to achieve good alumina hydrate quality. A variety of tank bottom designs are found in service including flat bottom, with or without fillet, and conical bottom. Conventionally, the tanks are fitted with draft-tube agitator, air lifting or multi-impeller agitation systems with baffles. Hydrate solids formed from precipitation out of the liquor, often deposit on unwanted locations such as the impeller shaft and hub, tank walls and upcoming risers. The mass of the accumulated scale can adversely influence sedimentation and mixing efficiency, lead to expensive cleaning/de-scaling operations, and compromise the tank integrity via draft-tube collapse or tank bottom bulging.

To overcome these challenges, SWIRLFLOW® mixing technology was jointly developed by CSIRO and QAL in the 1990s for use in alumina precipitation tanks. It has now been successfully installed in over 100 tanks of different sizes and duty around the world including tanks with flat, conical or filleted bottoms. This year (2023) at the Hindalco alumina refinery in India, SWIRLFLOW® was implemented in a precipitation tank of different design to those thus far - a tank with a filleted bottom and an inverted cone. This was the first installation of SWIRLFLOW® in India. At the time of writing this paper the precipitation tank has been running well and according to design for 4 months since commissioning, with the SWIRLFLOW® power consumption being within expectations from the laboratory design test work. The design, installation, and commissioning of the SWIRLFLOW® technology in this unusual tank type are discussed.

Keywords: Alumina precipitation tank, filleted bottom, Inverted cone, SWIRLFLOW®, implementation.

1. Introduction

SWIRLFLOW® was originally developed by a joint effort between CSIRO and Queensland Alumina Limited (QAL) as an alternative to the existing draft tube agitation system that was used in their precipitation tanks. Up to the time of writing QAL has successfully replaced draft tubes with SWIRLFLOW® in approximately 30 % of their precipitation tanks, while other alumina refineries around the world are now conducting plant trials with SWIRLFLOW®. Other than the alumina refineries, SWIRLFLOW® has also been implemented in a magnetite mixing tank in an iron ore operation [1], a gold CIP (Carbon-in-Pulp) tank, and a neutralization tank in a gold BIOX operation [2].

In alumina precipitation tanks scale formation can occur. Scale deposits on the tank internal surfaces and structures, adding significant weight to the structure which can cause damage including deformation of the tank and collapse of internal structures such as the draft tube, dip tube, etc. Excessive scale growth often results in high maintenance requirements, often tanks need to be taken offline before the scheduled maintenance, in several cases it can lead to unplanned shutdowns [3]. QAL has confirmed that SWIRLFLOW® has performed well in keeping the solids in suspension and has allowed the online time for precipitation tanks in the agglomeration stage and the precipitation tanks before and post interstage cooling to be increased.

So far, SWIRLFLOW® has been successfully implemented in precipitation tanks with tank bottoms such as conical bottom, fillet bottom and flat bottom tanks [4]. In 2022 the Hindalco Alumina refinery decided to implement the SWIRLFLOW® to replace a draft tube agitation system. Draft tube tanks are a known technology and are commonly used in other alumina refineries. The precipitation tank at Hindalco was different in that it has a fillet bottom with an inverted cone as shown in Figure 1. The functionality of SWIRLFLOW® is to generate a strong tornado in the center of the tank which provides strong uplifting flow to keep the solids in suspension. The precipitation tank at Hindalco has a bottom fillet which is likely to be more favorable for the SWIRLFOW®, however the concern with the central inverted cone at the bottom was whether it would obstruct the tornado, thus causing the tornado to slow down, which could potentially compromise the solids suspension performance.

This paper presents the results of a physical modelling campaign conducted in a scaled-down test rig in the CSIRO laboratory in Melbourne, Australia, to study and assess the performance of SWIRLFLOW® compared to the existing draft tube agitator design in an inverted cone tank. This formed the basis for an optimized design for the full-scale implementation as a trial at Hindalco's Muri alumina refinery in India.

2. Experimental Set Up

To design a suitable SWIRLFLOW® for the precipitation tank at the Hindalco refinery, a modelling study was conducted on a scaled-down test rig. Figure 1 shows the existing design scaled down, with details of the draft tube, slots and inverted cone. The modelling rig consists of an acrylic, transparent 1.0 m diameter cylindrical tank which was fitted in a square glass tank. The outer tank was filled with tap water to correct for optical distortion from the curved inner tank and to equalize the pressure difference between the inner cylindrical tank and the outer square tank. The impeller was fitted to the desired location on a central shaft which was driven by the motor via a VFD (Variable Frequency Drive) to allow the impeller speed to be changed. The shaft was instrumented with a speed detector and an Ono Sokki torque transducer, which were connected to a computer system that allowed for the impeller speed and torque to be logged. From the torque and speed, the power consumption and power number could be calculated. The modelling rig, as shown in Figure 2, was designed to allow for the option to change from a draft tube configuration to a SWIRLFLOW® configuration. The first part of the physical modelling was to study the performance of the draft tube, thus reproducing what was observed on the plant in the laboratory model.

The physical modelling work included making visual observations of the flow patterns in water and assessing the solids suspension performance by measuring the solids sedimentation height across a range of impeller speeds. The basic geometry and operating conditions of the laboratory

8. References

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