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Technical Note

A continuous pilot-scale flotation rig for the systematic study of flotation variables

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ABSTRACT

A pilot-scale flotation apparatus has been developed for the purpose of determining floatability parameters for an ore. It has the capability to vary many of the important flotation variables allowing them to be investigated independently. Adjustable factors include: cell size, froth depth, feed, tailings and air volumetric flow rates and reagent addition rates.

The flotation rig was commissioned successfully at BHP Billiton's Cannington mine in North-West Queensland, Australia. It was found to supply a stable feed stream with air well distributed across the cell. At the test conditions, the relative standard deviation of the calculated galena overall recovery was found to be only 1%.

Such an apparatus could prove invaluable in flotation research, allowing live streams from an operating industrial flotation plant to be processed continuously. The versatility of the design and accuracy of performance allow the investigation of most major flotation variables with confidence.

1. Introduction

There are two main approaches for determining floatability parameters for the Australian Mineral Industry Research Association (AMIRA) P9 flotation model (Gorain et al., 1998; Savassi, 1998). The Floatability Component Method employs batch flotation tests to fit floatability (P) to the P9 model (Runge et al., 1997); however, this approach is expensive and time consuming. In the physical-property-based approach all the other model parameters are determined and P is back-calculated from the model. The Floatability Characterisation Test Rig (FCTR) (Rahal et al., 2000) is a continuous pilot flotation plant used to back-calculate P from the model; however, the rig is difficult to operate and requires extensive sampling.

A single-stage pilot-scale apparatus has been built for the purpose of investigating the P9 model parameters, specifically P. Requisite features include: simple stable continuous operation, high reproducibility giving confidence in the determined parameters, access to all streams to give redundant data in mass balancing, access to the pulp volume for gas dispersion sampling, adjustable froth height and control of feed, air and reagent addition rates as well as impeller speed. This paper details the performance of the apparatus at a single, industrially relevant condition in terms of the variability of stream flows and cell overall, froth and pulp zone true flotation recoveries on an unsized basis.

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2. Description of the rig

The apparatus, originally designed and constructed as a high S_b cell (Vera et al., 1999), has been adapted to the design of a laboratory rig built previously at the JKMRC for ore floatability determination (Vianna et al., 2000). A photograph of the rig and some of its components is shown in Fig. 1. The rig can be operated continuously with 5, 20 or 40-L cells, or with a 5-L batch flotation cell. The entire apparatus is constructed from stainless steel, to minimise the impact of corrosion.

The 40-L cell used in the commissioning work is of square section (35 cm per side), and has the following features:

- Outotec style impeller mechanism surrounded by fixed stator.
- Bottom driven by electric motor with speed control.
- Adjustable height concentrate launder.
- Internal false wall allowing tailings to exit the cell.
- Fixed overflow weir, defining pulp level.
- Overflowing tailings sampled by gravity, tailings on cell side of weir pumped from base of weir.

The rig consists of the following components:

- Three 230-L capacity sumps.
- Three Lightnin electric mixers (model EV5P37) with two impellers per mixer.
- Bredel SPX25 peristaltic pump with variable speed drive for the feed.
- T-valve on feed line allowing sampling of the feed.

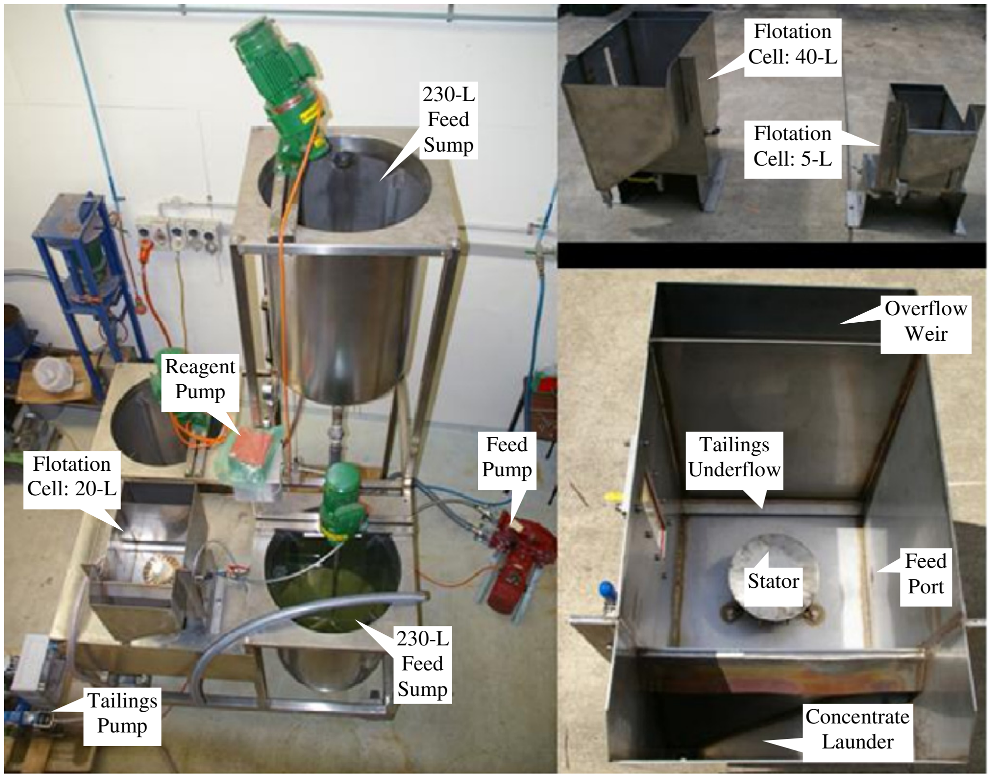

Fig. 1. Left: Pilot flotation rig with 20-L continuous cell, top-right: 40 and 5-L continuous cells, bottom-right: internal view of 40-L continuous cell (internally 35 cm per side). *Source*. S.M.S.M. Vianna

- T-piece on side of cell allowing in-line addition of reagents.
- Watson Marlow 101U/R Mk 2 peristaltic pump for frother addition.
- Verderflex 120 peristaltic pump with 0.37 kW motor and variable speed drive to remove tailings from cell side of overflow weir.
- Wash water nozzle on internal side of overflow weir, pushing settling particles into the tailings pump.
- Festo digital flow meter (model number SFE1-LF-F200-WQ8-P2I-M12) to read air flow rate (injected below impeller mechanism).

3. Operation of the rig

The operating procedure for the rig when used in continuous mode to treat a stream from an operating plant (which is its primary intended use) is described below:

- Switch on power.
- Start sump mixers.
- Fill feed sumps from plant (during commissioning they were set up as two feed sumps in series giving a total feed volume of 460-L).
- Add collector (in this case dissolved in beakers with process water) to feed sumps simultaneously and allow to condition.
- During conditioning set cell impeller speed and air flow rate to preliminary values for the test (these may change upon introduction of slurry to the cell).
- If required measure pH, Eh and dissolved oxygen demand in feed sump.
- After conditioning period start feed and frother pumps simultaneously (cell is initially filled with process water to avoid solids settling during filling).
- Start tailings pump.
- Adjust impeller speed and air flow rate until steady at required values.
- Allow to stabilise for four residence times to reach steady-state.
- Control feed sump levels such that half of the bottom sump is emptied, then filled with half of the top sump; once the bottom sump again empties to half, the remaining slurry in the top sump is emptied to the bottom. Terminate tests once the top impeller in the bottom sump begins to show. This procedure eliminates particle settling in either of the feed sumps.
- Sample tailings, concentrate and feed (in that order to minimise disruption to the cell).
- If required take cell characterisation measurements.
- Upon completion of test, the sumps, pumps and cell must be washed out thoroughly to remove any remaining solids or reagents. The pumps are stopped, the impeller speed decreased and the top sump cleaned, followed by the bottom one, with some fresh water added. This water is then pumped into the cell to flush the feed lines. The cell is drained, washed out and filled with fresh water. Some of this water is pumped through the tailings pump. The air is left on at all times to prevent blocking the line. The cell is then ready for another test.
- Measure the flow rate of wash water used in the overflow weir before and after a series of experiments to complete the cell water balance.

4. Characterisation of the rig

The rig was commissioned, characterised and tested with the 40-L continuous cell using the flotation plant feed stream at BHP Billiton's Cannington mine in North-West Queensland, Australia. Cannington is a silver-lead–zinc mine; the major minerals are galena, sphalerite and quartz. The reagents used were sodium ethyl