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Radial distribution of iron oxide and silica particles in the reject flow of a spiral concentrator

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ABSTRACT

Spiral concentrators are used in the iron ore industry to separate heavy iron oxide carrier particles from the light silica ones. Losses of iron occur mainly in the fine (−75 μm) and coarse (+600 μm) size fractions. This paper analyzes the radial distribution of iron oxide and silica particles in the reject of a 7 turn spiral. A splitter divides the reject flow into six (6) streams that can be sampled individually. Results show that coarse iron carrier particles settle mainly in the inner part of the spiral trough. Although fine iron particles are mostly concentrated in the outer part of the spiral trough, a significant proportion of these particles remain captive close to the concentrate ports. Coarse silica particles (+600 μm) are not concentrated in the innermost part of the spiral trough, while a significant concentration of silica particles in the size range of 75 to 212 μm is found close to the concentrate ports. This observation is coherent with the size of the silica particles that contaminate the spiral concentrate.

1. Introduction

Spiral concentrators classify particles according to their specific gravity and size (Wills and Napier-Munn, 2006). Large and dense particles are anticipated to move toward the inner zone of the spiral trough to be recovered as concentrate by collection ports. Fine and light particles travel to the outer area of the spiral trough and discharge the spiral as rejects. However, coarse particles of heavy minerals are also lost to the spiral reject (Sadeghi et al., 2014). These observations led to this investigation of the radial distribution of particles in the spiral reject.

In this study, a flow splitter is used to divide the reject of a spiral into 6 parallel streams that can be sampled individually. Ramotsabi et al. (2015) used a similar splitter in a study of the effect of wash water addition on spiral performance, but these authors did not provide the results concerning the radial distribution of particles according to their size nor density. Holland-Batt and Holtham (1991) used a similar device to trace quartz particles and glass balls in a spiral operated at a low slurry density. Holtham (1992) showed that the slurry solids concentration and the average particle size decrease outwardly. Loveday and Cilliers (1994) also used such a sampling device to highlight the complex interaction between particle size and density using a mixture of chromite and silica particles. Atasoy and Spottiswood (1995) made some observations about the radial distribution of particles for coal processing but it is difficult to apply the results to heavy mineral processing.

The results of such reject sampling are usually summarized at the end of a paper dedicated to the calibration of a model for spirals. This paper focuses on the observations of the radial distribution of particles at the discharge of a 7 turn spiral. Results are presented in terms of flow distribution, slurry solids concentration, species concentration and size distribution along the spiral trough. The objective of the paper is to add information about the iron ore processing in a spiral operated with wash water addition. The paper consists of four sections. The first section describes the experimental methodology. The second section presents a preliminary analysis of the measurements conducted through sampling campaigns. The following sections analyze the distribution of solids and some species across the spiral trough as a function of particle size and density.

2. Experimental conditions

This section describes the test set-up, the ore characteristics and the tests conditions. The collected measurements are described with the data processing method in the last part of the section.

2.1. Test set-up

Fig. 1 shows the test set-up which is installed at COREM, a research center in Quebec, Canada. The system is a closed circuit consisting of three parallel spirals (WW6E from Mineral Technologies) with 3, 5 and 7 turns. Wash water is used for these spirals. The diameter of each spiral is 613 mm with a 94 mm center column. The pitch is 357 mm. The spirals can be operated at identical wash water flow rate, slurry

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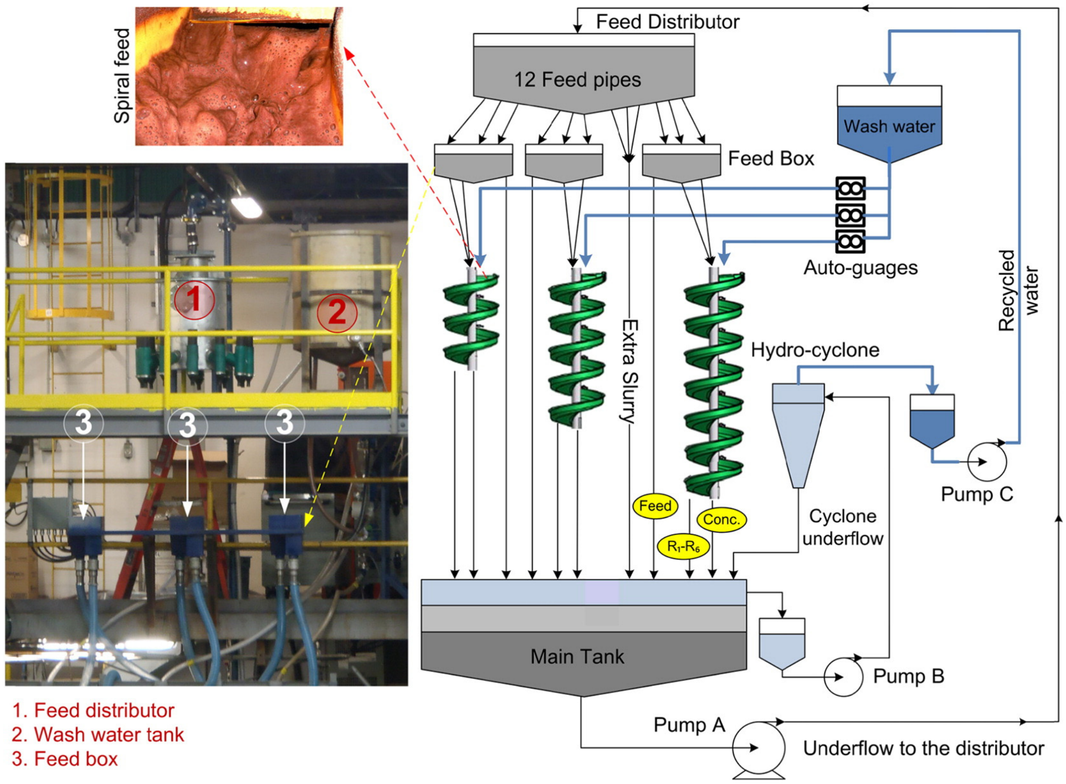

Fig. 1. Test rig installed at COREM.

solids concentration and feed rate, to assess the effect of the number of turns on the equipment performance. Only the results obtained with the 7 turn spiral are presented in this paper. The data concerning the operation of the 3 and 5 turn spirals can be found in Sadeghi (2015).

The ground ore and water are added into the main tank from where the slurry is pumped into a distributor that feeds 12 flexible pipes. Depending on the desired spiral feed rate 1, 2, or 4 pipes can be placed into a feed box for each spiral. Table 1 gives the characteristics of the slurry exiting the 12 feed pipes. Statistical results are also given in Table 1 to confirm that the distributor provides reproducible slurry flow rates, solids concentrations and composition to the 12 pipes. The relative standard deviation for the slurry flow rate and composition (Fe and SiO_2) is less than 5% confirming a good reproducibility. The solids flow rates exhibit the largest variability with a relative standard deviation of 8%.

The flow from each pipe exiting the distributor varies between 0.8 and 1.2 t/h depending on the slurry solids concentration. For the conducted tests only 2 pipes feed the 7 turn spiral, the rest is returned to the main tank to be pumped back to the feed distributor. The overflow of the main tank is pumped to four 5 cm diameter dewatering hydro-cyclones. The recovered water from the overflow is pumped to the wash water tank while the underflow returns to the main tank (see Fig. 1). The water recycling avoids a continuous dilution of the feed slurry as it would be the case if fresh wash water was used. The flow rate of wash water to a spiral is maintained to a set-point using a PID controller.

The spiral concentrate is collected by 2 cutters per turn except for the first turn where the cutters are closed to allow the initial sorting of the particles. The reject flow at the discharge of the spiral is divided into 8 streams by the splitter shown in Fig. 2. The innermost flow is combined with the concentrate stream in the central tube. The two

Table 1
Slurry characteristics in the 12 feed pipes from the distributor (see Fig. 1).

Feed pipes	% solids (%*w*/*w*)	Solids flow rate (t/h)	Slurry flow rate (L/min)	Fe content (%)	SiO_2 content (%)
1	32.1	1.1	57.8	30.1	54.5
2	33.2	1.2	58.0	30.7	53.9
3	34.1	1.2	57.8	31.4	52.9
4	33.9	1.2	57.5	30.7	53.7
5	34.0	1.2	59.8	30.9	53.8
6	34.4	1.2	57.8	31.2	53.0
7	32.7	1.2	59.3	30.8	54.0
8	30.5	1.0	56.5	29.5	55.3
9	30.0	1.0	56.3	29.3	55.5
10	28.3	1.0	59.1	28.4	56.7
11	29.7	1.0	56.3	28.7	56.2
12	30.0	1.0	55.9	29.1	55.5
Average	31.9	1.1	57.7	30.1	54.6
Stdev.	2.1	0.1	1.3	1.0	1.2
Rel. Stdev. (%)	6.6	7.8	2.2	3.4	2.3
Min	28.3	1.0	55.9	28.4	52.9
Max	34.4	1.2	59.8	31.4	56.7