PROCESS ROUTE FOR THE UNDERFLOW OF SAMARCO IRON ORE DESLIMING[1]

Antônio Eduardo Clark Perez [2]
Paulo Sérgio Mapa [3]
Marcos Gomes Vieira [4]

Abstract

This investigation addressed two products from Samarco's desliming circuit, namely underflow of cleaning cyclones and underflow of desliming cyclones. The roughing cyclones receive the product of the grinding circuit. The underflow of the roughing cyclones feeds the cleaning cyclones and the overflow feeds the desliming cyclones. The underflows of cleaning and roughing cyclones are combined to constitute the feed of the flotation circuit. These fractions were characterized and a new process route was proposed. The size distributions of the two fractions are quite different. The desliming cyclones underflow presents higher amount of material passing 37 μm and of ultrafines as compared with the cleaning cyclones underflow. Laboratory scale flotation tests were performed in a mechanical machine aiming at comparing the performances of these products in the presence of the reagents employed in the concentrator. Pilot scale column flotation yielded enhanced iron recoveries for both products in comparison with those achieved in laboratory mechanical cells, without impairing the concentrate quality. The increase in recovery was more significant in the case of the cleaning cyclones underflow. These results suggest the use of columns in the flotation of this product aiming at increasing the overall iron recovery. Nevertheless the results also showed that the use of columns to float the cleaning cyclones underflow should also be taken into consideration. Despite the fact that this product requires a longer residence time in order that the required silica content in the concentrate is achieved, the indication is that higher levels of iron recoveries might be reached. The conclusion is that, due to the different behaviors of the two products, they should be processed in distinct circuits to maximize the iron recovery.

Key words: Flotation routes; Desliming.

ROTA DE PROCESSO PARA O UNDERFLOW DA DESLAMAGEM DE MINÉRIO DE FERRO DA SAMARCO MINERAÇÃO S.A

Resumo

O processo de flotação catiônica reversa de minério de ferro, utilizando eteramina como coletor/espumante e amido de milho como depressor, ocupa papel estratégico em todas as grandes usinas brasileiras produtoras de *pellet-feed.* Um dos grandes desafios encontrados nessas usinas é o aumento da recuperação metálica, cujo fator preponderante é a redução da perda de minerais de ferro no flotado, por arraste ou flotação verdadeira. Neste trabalho, buscou-se a caracterização dos dois produtos provenientes da deslamagem (*underflow* dos ciclones limpadores e *underflow* dos ciclones deslamadores) que constituem a alimentação do processo de flotação em células mecânicas da usina de concentração da Samarco e a proposição de uma nova rota de processo. Foram feitos testes de flotação em célula mecânica de laboratório, no intuito de comparar o desempenho desses dois produtos em relação aos reagentes comumente utilizados na usina de concentração, tendo sido constatados diferentes comportamentos de cada um dos produtos em estudo. Ensaios de flotação em coluna piloto resultaram na obtenção de melhores índices de recuperação metálica, tanto na flotação do *underflow* dos ciclones limpadores quanto na flotação do *underflow* dos ciclones deslamadores, comparativamente com a utilização da célula mecânica de laboratório, sem prejuízos na qualidade do concentrado. O incremento na recuperação metálica foi mais expressivo na flotação do *underflow* dos ciclones deslamadores.

Palavras-chave: Rotas de flotação; Deslamagem.

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[2] *Professor, PHD – UNIVERSIDADE FEDERAL DE MINAS GERAIS*

[3] *Process Specialist, Msc – SAMARCO MINERAÇÃO*

[4] *Senior Process Engineer, CQE – SAMARCO MINERAÇÃO*

1 INTRODUCTION

The reverse cationic flotation of iron ore plays a strategic role in all Brazilian concentrators producing pellet feed fines.

Iwasaki (1983) stressed the potential of the method for the concentration of low grade oxide ores.

Li et al. (1993) addressed the basic principles of flotation as surface chemistry and hydrodynamics. It was also emphasized the relevance of particle size in a flotation system, even if this variable is not considered in the evaluation of process performance.

Castro and Cruz (2003), investigating the differences between flotation performances consisting of a combined fraction -150μm and another sample split into fractions -150μm +38μm and -38μm, observed distinct behaviors, with indication of deleterious action of one size range towards the other in the case of the combined flotation. The recommendation was defining parameters for splitting the flotation into two size ranges, coarse and fine particles.

A relevant parameter for evaluating iron ores flotation performance is the iron metallurgical recovery. Its maximization is vital for a profitable business providing a longer life to both, the available reserves and the tailings ponds.

The processing of lower grade complex ores, at lower flotation rates of gangue minerals and increasing feed rates to compensate the smaller weight recoveries due to decreasing head grades, impaired the iron metallurgical recovery, for ultrafine particles of iron minerals report to the froth product, via either true flotation or entrainment. This metallic recovery drop motivated investigations addressing enhancing the levels of recovery. One of the research lines was the characterization of two products from desliming (underflow from cleaning cyclones and underflow from desliming cyclones), which constitute the feed of the mechanical cells flotation circuit at Samarco's concentrator, aiming at proposing an alternative flotation route. Figure 1 illustrates the desliming flowsheet at Samarco.

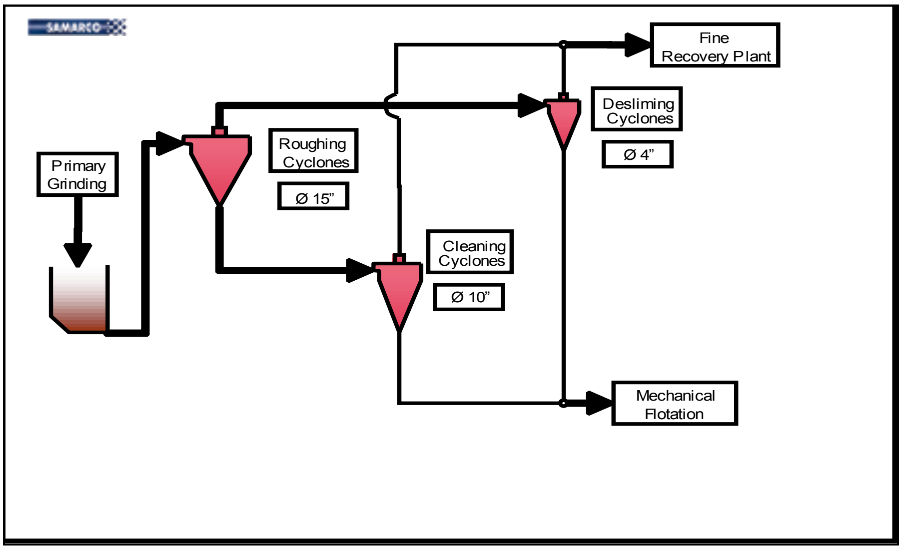

Figure 1 – Desliming flowsheet at Samarco's concentrator

2 EXPERIMENTAL

Experimental work included samples preparation and characterization, and technological testwork.

2.1 Samples Composition and Preparation

Samples from the cleaning and desliming cyclones underflow products were composed during 30 days. Two sampling campaigns were performed in the four desliming lines every day, during five minutes each, with increments collection every 5 minutes, to warrant that the sample was representative of the concentrator routine.

The samples were dewatered, homogenized, and stored. Each increment was filtered in a press filter, dried in a kiln at 110^{0}C and disaggregated. Homogenization was performed in conical piles and Jones riffles were used to quarter the samples for the flotation experiments.

2.2 Samples Characterization

Size analyses were performed with the use of Tyler series sieves in a Rotap apparatus. A size analyser based on the Laser principle was employed at the fines size range. Chemical analyses were performed for each narrow size range.

2.3 Technological Testwork

Reverse cationic flotation experiments were carried out in a mechanical laboratory machine and also in a pilot scale column.

The aim of exploratory experiments in the mechanical cell was to study the individual behavior of the underflow from each cyclones circuit in the presence of the flotation reagents used in the flotation process at Samarco's concentrator (ether monoamine, ether diamine and corn starch).

The tests were conducted in a 2.4L Wemco cell, operated at 1300rpm. The iron oxides depressant was corn starch gelatinized with caustic soda (NaOH) at the weight ratio 5 (starch): 1 (NaOH). The depressant solution was prepared at a concentration 1% (w/v) and the caustic soda solution was prepared at 3% (w/v). Both amines (Flotigam EDA-3 ether monoamine; Flotigam 2835-2 ether diamine) were supplied by Clariant and were combined at the ratio 1:1. The collector solution was diluted to 1% (v/v).

The pilot scale tests aimed at investigating the possibility that the two materials might respond differently to column flotation, in comparison with flotation in mechanical machines. The column dimensions are: total height 4.3m; feed inlet height 2.8m; diameter 0.1m.

The test conditions are described next:

- depressant: corn starch solution 1% (w/v), starch : NaOH ratio 5 : 1;
- collector: ether diamine (Flotigam 2835-2) solution 1% (w/v);
- depressant conditioning time: 15min;
- flotation pH: 10.5, adjusted with NaOH;
- weight % solids in flotation: 40%;
- feed rate: 0.05t/h;
- froth layer height: 80 to 90cm;
- air flow rate: 9NL/min;
- gas hold up: 8.07%;
- wash water flow rate: 100L/h
- residence time: 7min.

3 RESULTS AND DISCUSSION

3.1 Size Analyses

Results of size analyses of the cyclone underflow fractions using screening and a Laser size analyser (Mastersizer) are presented in Figure 2.

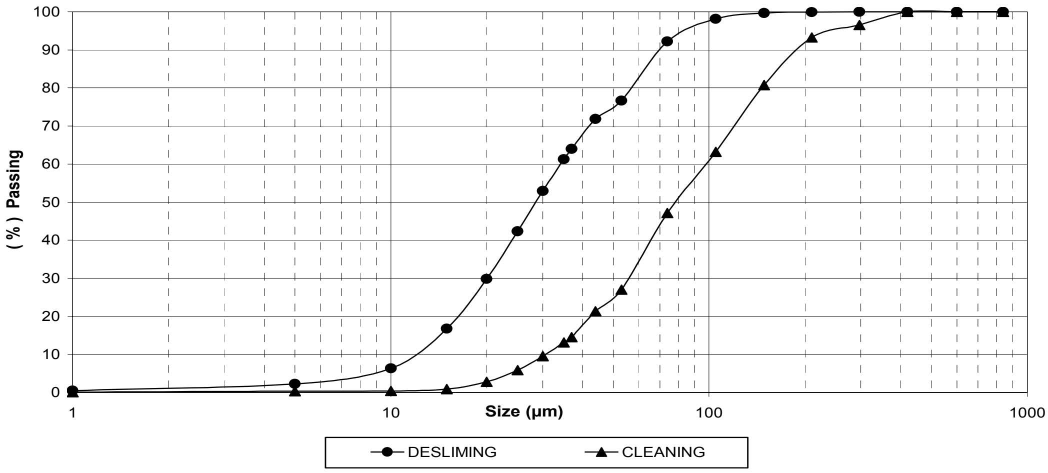

Figure 2 – Size distribution of the underflow of the cleaning cyclones and underflow of the desliming cyclones.

The underflow from the desliming cyclones presents a high percentage of material passing 37µm, approximately 64%, and 6% of ultrafines (-10µm). On the other hand, the underflow from the cleaning cyclones presents only 15% passing 37µm, and 0.5% ultrafines.

3.2 Chemical Analyses

The results of chemical analyses by size range are presented on Tables 1 and 2.

Table 1 – Chemical analyses of the underflow of the cleaning cyclones by size range.

Size range	Fe (%)	SiO_2 (%)	Al_2O_3 (%)	P (%)	LOI (%)	MnO_2 (%)
+210µm	48,53	26,48	0,58	0,051	3,39	0,050
-210+149µm	41,17	38,76	0,22	0,026	2,06	0,040
-149+105µm	37,51	44,64	0,17	0,020	1,50	0,020
-105+74µm	39,09	42,56	0,15	0,018	1,34	0,020
74+53µm	50,03	26,87	0,16	0,021	1,37	0,020
-53+44µm	57,75	15,98	0,19	0,017	1,22	0,010
-44+37µm	60,93	11,60	0,16	0,016	1,08	0,010
–37µm	64,83	6,13	0,17	0,019	0,96	0,010
Global analysed	49,44	27,57	0,17	0,028	1,49	0,020

Table 2– Chemical analyses of the underflow of the desliming cyclones by size range

Size range	Fe (%)	SiO_2 (%)	Al_2O_3 (%)	P (%)	LOI (%)	MnO_2 (%)
+105µm	10,12	83,16	1,12	0,004	1,23	0,010
-105+74µm	5,52	91,50	0,22	0,004	0,37	0,010
74+53µm	10,38	84,42	0,17	0,004	0,55	0,010
-53+44µm	21,44	68,12	0,23	0,014	0,96	0,010
-44+37µm	29,58	56,22	0,27	0,021	1,16	0,010
–37µm	57,65	15,58	0,37	0,025	1,55	0,020
Global analisada	39,46	42,00	0,28	0,024	1,24	0,010

3.3 Exploratory Laboratory Flotation in Mechanical Cells

The results of the tests conducted on the underflow of the cleaning and desliming cyclones individually are shown in Table 3. The experiments were planned according to the factorial design method.

Table 3– Results of the laboratory flotation experiments with the underflow of the cleaning cyclones and underflow of the desliming cyclones (mechanical machines).

Collector (%)		Dosage (g/t)		Cleaning		Desllming	
EDA-3	F 2835-2	Starch	Coletor	SiO_2 (%)	Fe recovery (%)	SiO_2 (%)	Fe recovery (%)
100	0	300	40	2,17	80,22	2,72	58,04
100	0	600	40	3,13	88,80	1,14	66,62
100	0	300	60	1,95	77,93	1,87	52,19
100	0	600	60	2,23	86,29	0,90	62,57
50	50	450	50	1,77	84,27	0,89	65,91
0	100	300	40	1,92	88,28	2,22	76,86
0	100	600	40	2,42	90,69	3,01	80,27
0	100	300	60	1,54	84,83	1,30	71,03
0	100	600	60	1,66	87,51	0,99	71,60

The criterion for planning the experiments was a full factorial design screening 2^3, at two experimental levels, capable of discriminating strong effects of factors and also the main interactions among them.

The results were analysed with the help of the statistical software Statgraphics Plus version 3.0. In the analysis Pareto plots of the effects were used, larger effects indicating a stronger influence of the factor on the experimental response.

The levels of the parameters investigated (factors) were selected based on the industrial practice:

- collector type: ether monoamine or ether diamine
- collector dosage: 40 and 60g/t
- depressant dosage: 300 and 600g/t

Figure 3 presents the Pareto plots of the 2^3 factorial design method experiments, illustrating the effects of the variables and their interactions on the experimental response silica content in the concentrate. The vertical line separates the significant effects, to the right, from the less significant effects, to the left, at 95% confidence level.

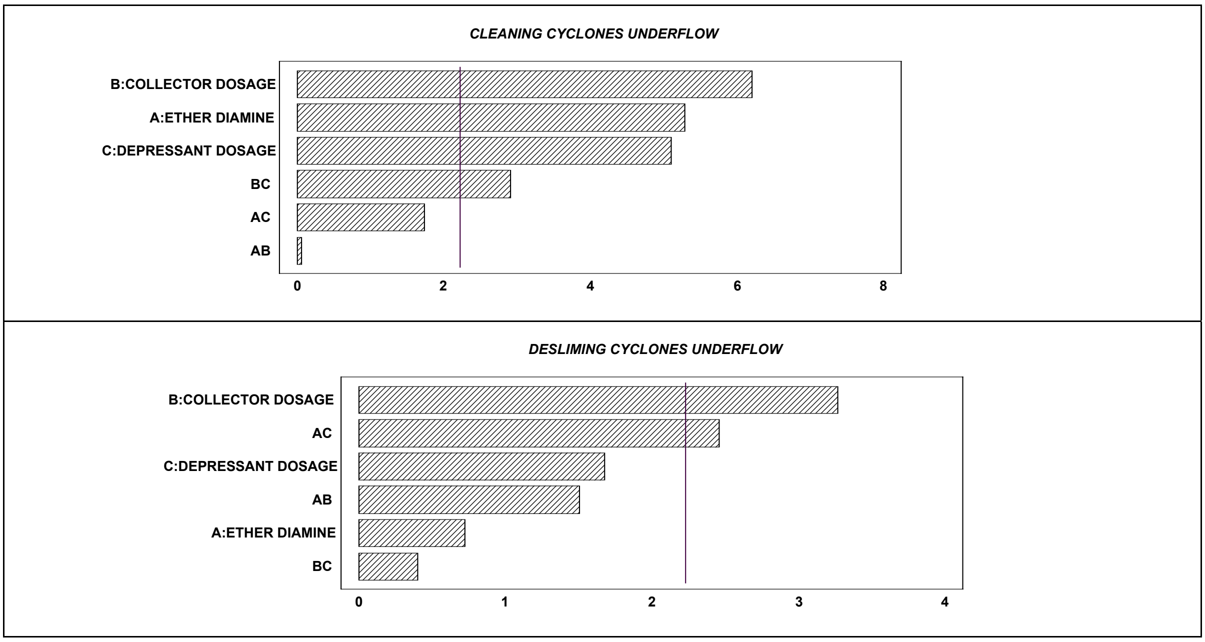

Figure 3 – Pareto plots for the experimental response silica content in the concentrate.

The plots on Figure 3 indicated that collector dosage was the most significant variable regarding the experimental response silica content in the concentrate in the flotation of the underflow of the cleaning cyclones. The other variables in the decreasing sequence of significance were the participation of ether diamine, the depressant dosage, and the interaction between collector and depressant dosages.

In the flotation of the underflow of the desliming cyclones, the most significant variable concerning the experimental response silica content in the concentrate was also the collector dosage, followed by the interaction between the participation of ether diamine and depressant dosage. The other factors and interactions did not affect significantly the silica content in the concentrate.

The Pareto plots on Figure 4 illustrate the effects of variables and their interactions on the metallurgical recovery.

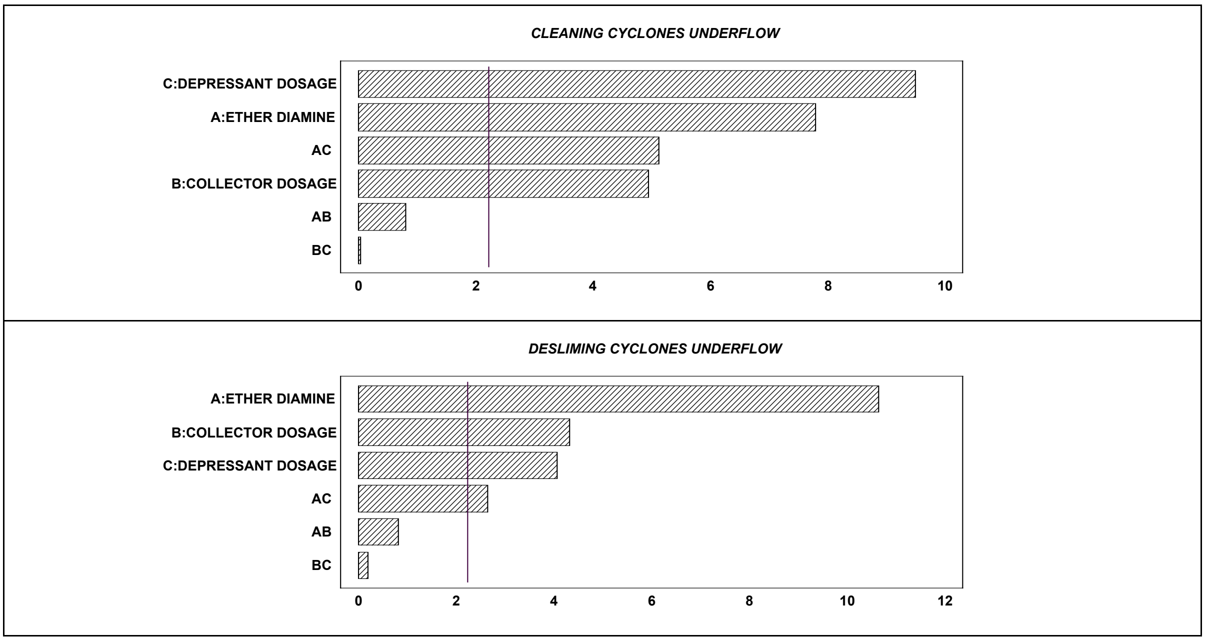

Figure 4 – Pareto plots for the experimental response iron recovery

It may be observed from the analysis of Figure 4 that the depressant dosage was the most significant factor affecting the metallurgical recovery in the flotation of the underflow of the cleaning cyclones. The other variables in the decreasing sequence of significance were participation of ether diamine, interaction participation of ether diamine and depressant dosage, and collector dosage.

In the flotation of the underflow of the desliming cyclones, the most significant variable concerning the experimental response metallurgical recovery was the participation of ether diamine, followed by the collector dosage and the interaction between the participation of ether diamine and depressant dosage.

3.4 Pilot Scale Flotation Tests

The definitions on the participation of ether diamine and collector dosages were based on the usual plant practice at Samarco's concentrator.

Three tests were conducted in the pilot flotation column with each product. At the same time tests were performed in a laboratory mechanical cell. Average results for each product are presented in Table 4.

Table 4 - Average results of flotation tests in mechanical machine and flotation column.

Product	Machine	Dosage (g/t)		SiO_2 (%)	Recovery (%)
		Starch	**Collector**		
Underflow cleaning cyclones	Column	300	40	1,50	93,5
	Mechanical			2,31	89,28
Underflow desliming cyclones	Column	600	50	1,04	94,35
	Mechanical			1,00	75,52

A comparison between tests conducted in mechanical machines and flotation column shows that higher iron recovery levels are achieved with the column, without impairing the quality of the concentrate.

The enhanced recovery was more expressive in the flotation of the underflow of the desliming cyclones (75.52% in mechanical cells; 94.32% in column).

4 CONCLUSIONS

The factors participation of diamine, collector dosage, depressant dosage, and their interactions affect the flotation performance of the products underflow of cleaning cyclones and underflow of desliming cyclones in different ways. The two products present distinct behaviors in the presence of the reagents used in Samarco's plant practice.

The use of the flotation column yielded higher iron recoveries for both products, in comparison with the mechanical laboratory machine, without impairing the quality of the concentrate.

Column flotation is a more promising technique for the finer product, the underflow of the desliming cyclones.

Column flotation is also promising in the case of the underflow of the cleaning cyclones but, due to the coarser size distribution of the particles, longer residence times are required.

Diverting the two products to distinct flotation circuits, operated under conditions adequate to the characteristics of each one, is suggested to maximize the iron recovery at Samarco's concentrator.

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