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PROCESS WATER REUSE IN IRON ORE FLOTATION: REDUCING AMINE CONSUMPTION

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ABSTRACT – This study aimed to evaluate the reuse of process water through the immediate recirculation of water from reverse cationic flotation of iron ore in subsequent flotation cycles, focusing on reducing water and ether-amine consumption. Bench-scale flotation tests were conducted in rougher and cleaner stages using water from three different streams of an iron ore beneficiation plant located in Brazil. The recirculation of water containing ether-amines, originating from the concentrate and flotation stages, allowed for a gradual reduction of ether-amine dosage per cycle, totaling more than 15% savings over five cycles, without compromising mass and metallurgical recovery. The concentrates achieved iron grades above 67% and SiO2 levels below 2.6%, regardless of the water source used. Therefore, the results demonstrate technical feasibility at laboratory scale (technology readiness level 4) for saving water and ether-amines in the process, with potential for industrial-scale application.

Keywords: Process water reuse, Iron ore flotation, Water management, Ether-amine, Sustainable mining.

INTRODUCTION

Reverse cationic flotation is a technique widely used in the mineral industry to concentrate iron ores. In this process, fatty amines act as collectors, promoting the flotation of silica, while starch is used as a depressant for iron minerals, ensuring selectivity and making it possible to obtain concentrates with suitable commercial specifications [1]. Water recirculation is a common practice in mining companies, especially in processes that require large volumes of this resource, such as flotation [2, 3]. This strategy allows for the reuse of water from stages such as thickening and dewatering, reducing the consumption of fresh water and making it possible to recover residual amines present in the process water.

Different strategies for recovering and reusing amines have been studied. Oliveira *et al.* [4] found that more than 60% of the amine can be recovered by desorption from quartz. Alternatively, adsorbents such as angelim sawdust, sugarcane bagasse and

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zeolites have shown high efficiency in the removal and recovery of amines [5-7]. In addition, studies indicate that the recirculation of water containing residual amines can reduce reagent consumption by up to 50% without compromising flotation efficiency [8-11]. Monte *et al.* [12] demonstrated that the reuse of water containing residual amine reduced the consumption of new amine by 46%, maintaining the quality of the concentrate at 68% Fe and 1.3% SiO_2.

The continuous recirculation of this water can lead to the accumulation of dissolved ions and organic compounds, which influence the interaction between the reagents and the minerals, compromising the selectivity of the flotation and the quality of the concentrate [13-14]. In addition, the interaction between amine and starch is sensitive to variations in pH, reagent concentration and conditioning time, making the behavior of the system even more complex [1,4,11]).

Despite the advances in reagent reuse, most studies have been conducted with distilled water, disregarding the effects of real process water. In this study, it was evaluated the feasibility of progressively reducing the ether-amine dosage in five sequential cycles of reverse flotation, on a laboratory scale and using process water collected at different points in a plant.

This study seeks to understand how the recirculation of process water can affect the quality of the concentrate, offering a more representative approach to industrial conditions.

MATERIALS AND METHODS

Bench scale flotation tests

Flotation tests were conducted at bench scale using a CDC-type flotation cell. The flotation circuit consisted of Rougher and Cleaner stages, with analyses carried out considering water recirculation over five cycles.

The process water used in these tests originated from a mining operation in the Quadrilátero Ferrífero (Iron Quadrangle) region, Brazil, and three different sources were evaluated, namely Tailings Overflow (OF/T), Concentrate Overflow (OF/C), and Scavenger Cell.

Recirculated water was obtained by combining the water recovered in the first cycle from the Rougher and Cleaner stages, forming a composite sample used to feed the subsequent cycles. The flotation process was carried out at 60% solids during conditioning. In the rougher stage, flotation was conducted at 50% solids for 2 minutes, while the Cleaner stage proceeded until froth exhaustion.

A gelatinized starch solution treated with sodium hydroxide (NaOH) was used as a depressant for hematite at a fixed dosage of 550 g/t, with a conditioning time of 6 minutes.

For quartz flotation, the ether-amine collector Flotigam 7100, a commercial reagent supplied by Clariant (Brazil), was employed. Sodium hydroxide (NaOH) and hydrochloric acid (HCl) solutions were used as pH regulators, maintaining the flotation at pH 10.3. The collector conditioning time was set at 1 minute. The starting ether-amine dosage was 180 g/t of silica, decreasing by 5% per cycle, totaling a 20% reduction by the fifth cycle (144 g/t).

RESULTS AND DISCUSSION

The ore sample used in the flotation tests was chemically analyzed by X-ray fluorescence (XRF) and its particle size distribution was determined by sieving. The initial sample contained 43% Fe and 37% SiO_2. Particle size analysis showed that 86% of the material was finer than 106 µm, with 46% passing through the 45 µm sieve.

Figures 1, 2, and 3 present the concentration of ether-amine in starting liquid phase, ending liquid phase, and solid phase (total ether-amine concentration adsorbed on solid phase) in each cycle, as well as new ether-amine and recirculated ether-amine in each cycle in recirculating water from the three process water flows containing residual ether-amine — Tailings Overflow (OF/T), Concentrate Overflow (OF/C), and Scavenger Cell. In Figures 1-3 it can be observed that recirculating water allowed for a gradual reduction in collector dosage per cycle, culminating in a total saving of 15% after five cycles.

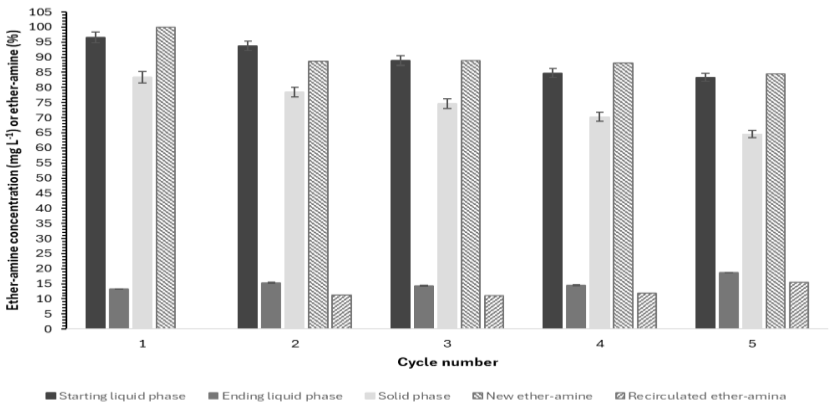

Figure 1 Ether-amine concentration and their amount in each flotation cycle using water from tailings overflow (OF/T)

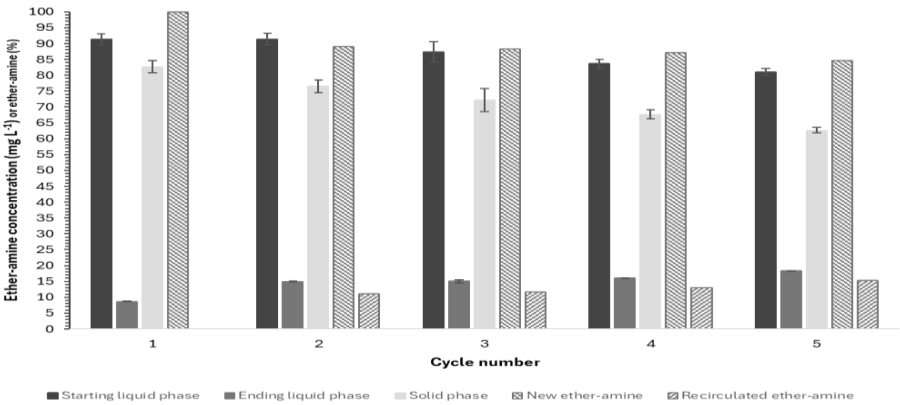

Figure 2 Ether-amine concentration and their amount in each flotation cycle using water from concentrate overflow (OF/C)

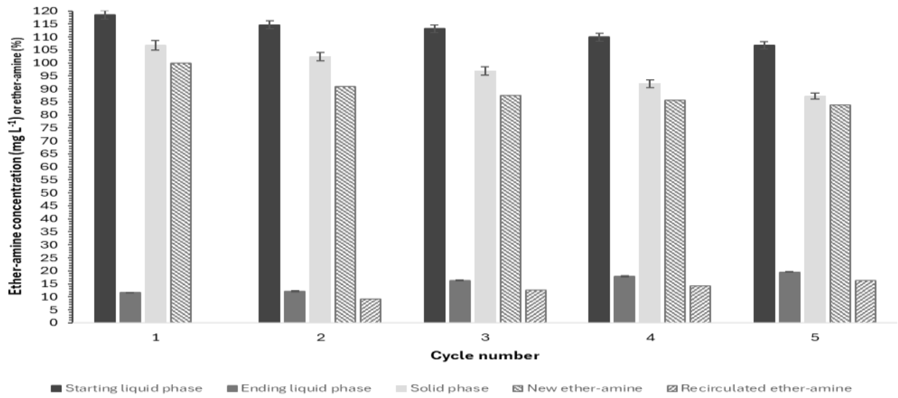

Figure 3 Ether-amine concentration and their amount in each flotation cycle using water from Scavenger cell

The results presented in Figures 4, 5, and 6 show the metallurgical and mass recovery (flotation yield), and quality concentrates (Fe and SiO_2 grades) using recirculating water from the three process water flows containing residual ether-amine.

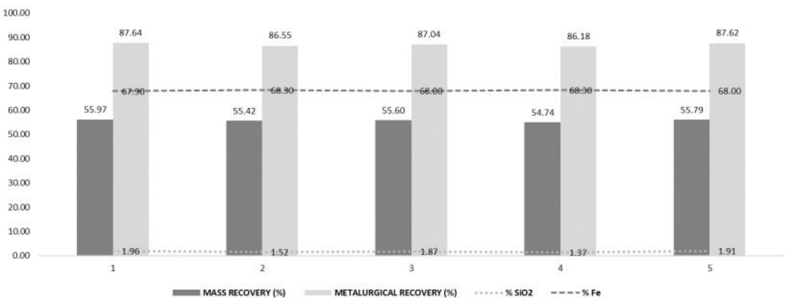

Figure 4 Mass and metallurgical recoveries, Fe and SiO_2 grades of the concentrates from each flotation cycle using water from tailings overflow (OF/T)

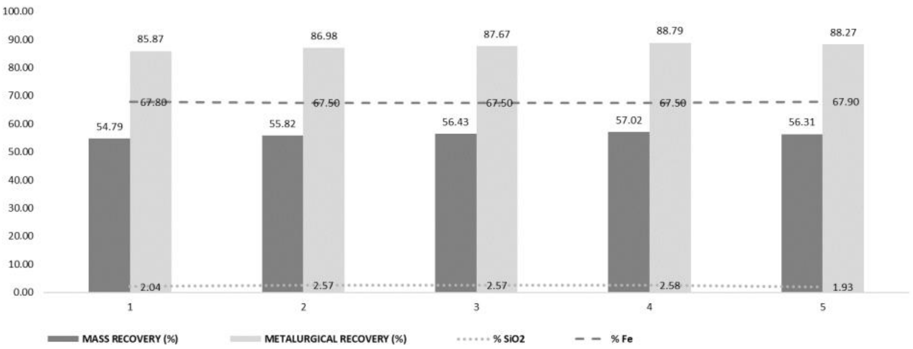

Figure 5 Mass and metallurgical recoveries, Fe and SiO_2 of the concentrates in each flotation cycle using water from concentrate overflow (OF/C)

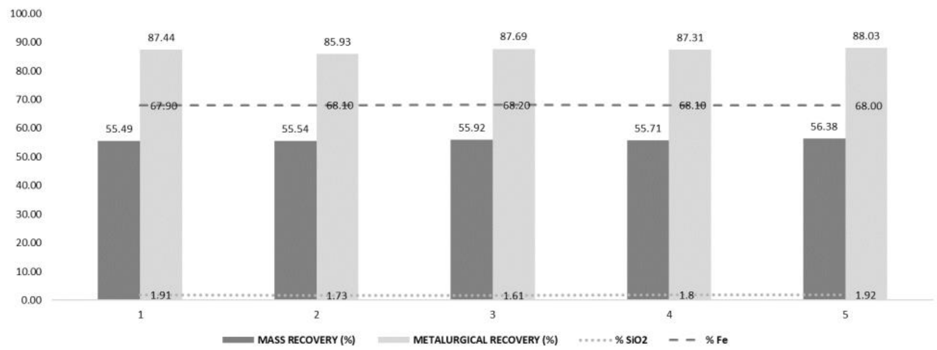

Figure 6 Mass and metallurgical recoveries, Fe and SiO_2 grades of the concentrates from each flotation cycle using water from Scavenger cell

As observed, the reduction of amine dosage did not compromise either the metallurgical recovery of the concentrate, which remained stable between 85% and 89%, or the iron grade of the concentrates (>67%) and mass recovery that ranged from 55.5%-56.3% for the different water flows. Tests using Concentrate Overflow (OF/C) water yielded the highest average mass recovery (56.3%), and metallurgical recovery (87.5%).

For the Rougher Tailings, the metallurgical recovery ranged from 6.24% (Scavenger Cell), 7.3% Tailings Overflow (OF/T), 7.4% Concentrate Overflow (OF/C). In the Cleaner Tailings, the metallurgical recovery ranged from 6.5% (Scavenger Cell), 5.76% (Tailings Overflow), 5.1% Concentrate Overflow (OF/C). The greatest iron loss in the cleaner tailings were observed in tests using water from the Scavenger Cell flow.

CONCLUSION

The recirculation of process water containing residual ether-amine allowed savings of more than 15% in the consumption of the new collector over five cycles, without compromising metallurgical recovery and iron content. Metallurgical recoveries remained between 85.0% and 89.0%, while the iron content of the concentrates remained above 67.0%. This reduction in reagent consumption represents an advance in process efficiency, reducing operational costs and environmental impacts associated with the disposal of chemical products. Finally, the industrial application of the technique requires additional studies to ensure its long-term stability and economic viability (TRL > 4).

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