THE EFFECT OF pH ON FROTH PROPERTIES[1]

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Abstract
Cationic reverse flotation is extensively used to process Brazilians iron ores. Amine, a polymeric reagent, is used as collector and frother in this type of concentration. Vale's Vargem Grande Complex, located at Iron Ore Quadrangle, is one of the biggest Brazilian producers. After flotation, the floated material, containing the gangue, follows to a box, from which the material is pumped to the tailing disposal area. The difference level between the pumping and the discharge points is surpassed by two series centrifugal pumps. The pumping capacity is affected by slurry froth factor. This study aimed to investigate the effect of pH control on froth stability. Froth stability tests were carried out in laboratory scale using carbonic gas and a coagulant, ferric sulphate solution, over a pH range from 5 to 14. The experimental data of froth height as a function of time was recorded. These results supported the identification of the best conditions for froth destabilization and allowed to establish new operational conditions of Vargem Grande floated pump system. The use of regulators, carbonic gas and ferric sulphate, as a pH controller was efficient to reduce the froth stability. However ferric sulphate addition showed the best process feasibility and cost.
Key word: Froth; Froth stability; pH control.

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1 INTRODUCTION

Vale is the major iron ore producer, reaching, in 2010, almost two hundred and seventy million tons of iron ore fines. Vargem Grande industrial facility, located in Brazilian Iron Ore Quadrangle, produces 18.8 millions ton per year of iron concentrate and the pellet feed represent almost 10% of the total production. The concentrate plant is composed, mainly, by a homogenizing pile, screenings, desliming cyclones, flotation columns, thickeners and vacuum filters.

In 2008, a new tailing dam, located 6 km away from the concentration facility, started to receive the flotation tailings. The pump system has two lines and each one is composed of one 6.6 m³ slurry box, two froth pumps set in series, equipped with 125hp motor and frequency charger and 400 m of 8" tubes. The discharge point, in a slurry tank, is located 27 m higher than the pumps. From this tank the slurry is pumped over again until the tailing dam.

The floated materials were presenting an excessive froth formation, which were jeopardizing pump system capacity and leading to operational problems.

Amine, a reagent that disassociates in water such as Equation 1, is used as collector and frother in the iron ore cationic reverse flotation. Araujo, Viana and Peres(1) stated that the ionic phase is responsible for the gangue and quartz collection, while the non-ionic phase is responsible for decreasing water surface tension and, thus, froth stability maintenance.

$$RNH_2 + H_2O \longleftrightarrow RNH_3^+ + OH^- \qquad (1)$$

The pH in which amines stared to disassociate are reagent chemistry dependent. Leja(2) stated that the concentration of ionic amine is equal to 50 % in pH 10.5. Smith and Akhatar(3) studied dodecylamine ionization and concluded that ionic phase starts to decrease at pH 10. Vidyadhar, Rao and Forssberg,(4) for instance, found out the charged amine species are predominant below pH 6.5.

Furthermore amine quantification in industrial flows is a very difficult task. Firstly, the sample must be analyzed as soon as possible, since amine concentration decreases as the time pass by. Chaves(5) monitored a decrease equal to 84 % in twelve days. Secondly, some methods do not provided trustful information. Turrer et al.(6) used two methods to measure anime concentration in an effluent and just one, patented by Araujo, Yoshıda and Carvalho,(7) could detect it.

Usual values of amine concentration in iron ore flotation tailing samples measured by the method described for Araujo, Yoshıda and Carvalho(7) vary between 5 and 40 mg/l.

Iglesias et al.(8) proposed a mathematical model (Equation 2) to describe froth height as time function. Since the zero time is not well defined, it is better to base the half decay on the height value. Thus the reference is taken as the time $t_{1/2}$ at which the column height $H_{1/2}$ is half the original height H_0 reached by the Bikerman's method dynamic equilibrium. The data are then replotted in a dimensionless form as H/H_0 vs. log $(t/t_{1/2})$. It is expected that all the straight lines would pass through the central point of the diagram, point (1/2, 0). The equation's angular coefficient, α, represents the froth stability, which allow to quantify the effect of additives on the decay of several foam systems.

$$\frac{H}{H_0} \longleftrightarrow -\alpha \times \log\left(\frac{t}{t_{1/2}}\right) \qquad (2)$$

Aiming to confirm that amine concentration and/or effluent alkalinity increase were affecting froth formation in the tailings, a simple laboratory experiment was applied. Based in the results found, actions were taken to decrease froth stability.

2 METHODOLOGY

A laboratory procedure was developed to quantify froth formation in different conditions. One litre test tubes were filled with distillate water until complete seven hundred millilitres. Afterwards amine solution was added, in different concentrations, such as 1.4 7, 36 and 60 mg/l. The reagent used was a commercial mixture of propylamine ether isonyl and its acetate, supplied by Clariant and named EDA-C. The pH was adjusted to higher levels with sodium hydroxide addition. Separately, carbonic gas and ferric sulphate where aplied to decrease pH level. After pH adjustment, the solution was mixed forty times using a plunger. The froth volume was recorded as a function of time passed after mixing, as showed in Figure 1.

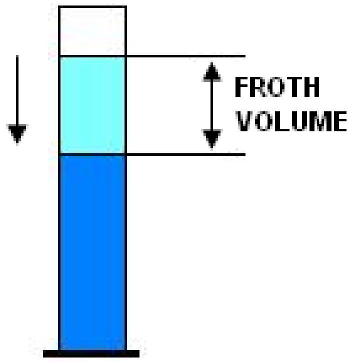

Figure 1. Froth volume recording in a laboratory tube.

3 RESULTS AND DISCUSSION

The results were firstly plotted in a graph of froth volume as a function of time passed after mixing, as showed in Figure 2. In this figure, pH was decreased by ferric sulphate solution addition and amine concentration was 36 mg/l. Similar graphs were analyzed for different amine concentrations, from 1.4 to 60 mg/l, and using different pH controllers, namely, carbonic gas and ferric sulphate.

As stated by Iglesias et al.,[8] graphs such as Figure are hard to interpreted the froth decaying pattern and reach assertive conclusions. Thus, the procedures described by those authors were applied to draw the dimensionless plot illustrated in Figure 3. The angular coefficients represent the froth stability and, in this case, are proportional to pH, which means, pH increase will lead to froth stability increase. This behaviour was observed to the others amine concentrations, excluding 200 mg/l, when pH presented no effect in froth stability. However, in accordance with Silva et al.,[9] this concentration is not expected to be found in iron ore concentrator effluents, even in the tailings.

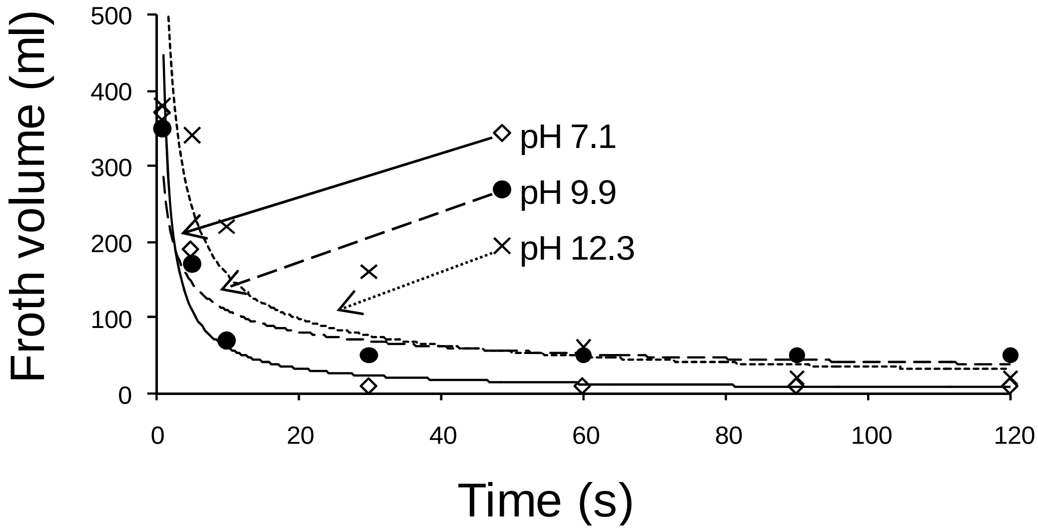

Figure 2. Reduction of froth volume as a function of time and pH (amine concentration equal to 36 mg/l and ferric sulphate addition to pH decrease).

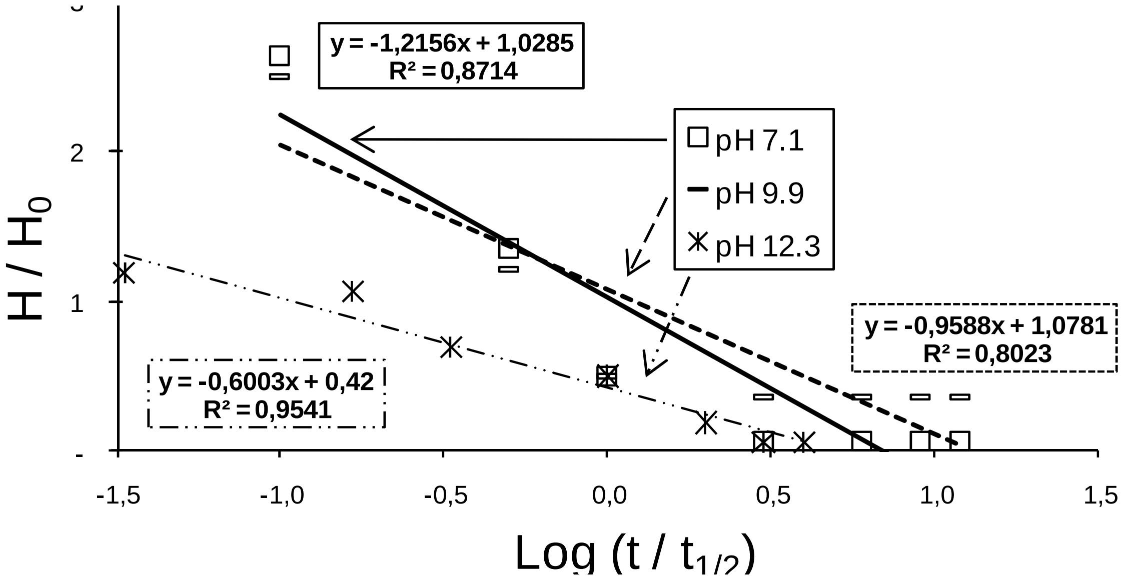

Figure 3. Dimensionless plot for solutions with amine concentration equal to 36 mg/l and and ferric sulphate addition as pH controller.

The effect of pH controller in froth stability was also evaluated. The results showed that the pH controller used has small effect in froth destabilization, since angular coefficients were quite similar. The results for amine concentration equal to 36 mg/l that allowed reaching this conclusion are presented in Figure 4.

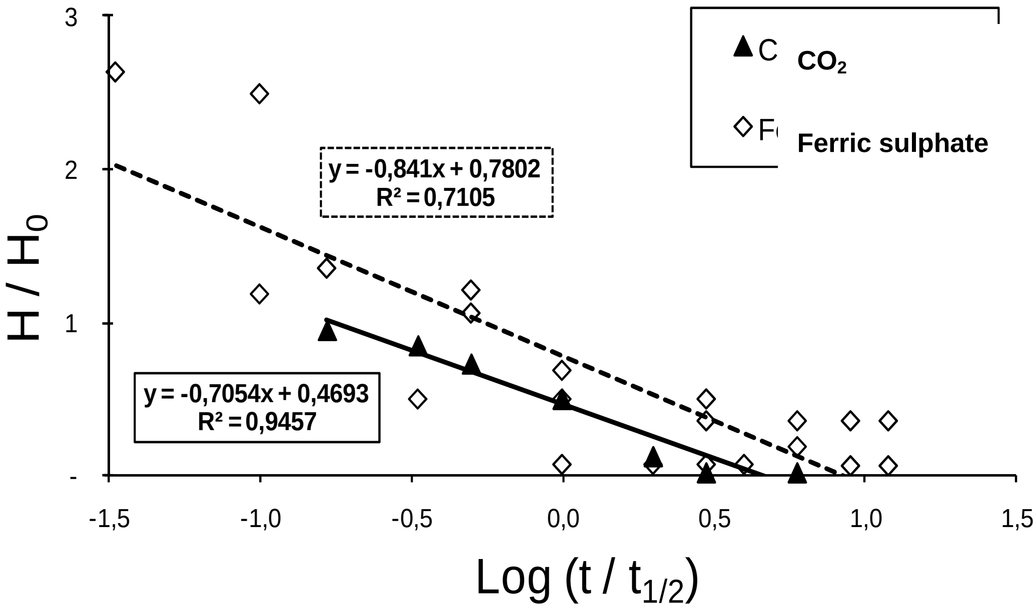

Figure 4. Dimensionless plot for solutions with amine concentration equal to 36 mg/l using different pH controllers.

Since carbonic gas would need the installation of a properly and specific dosage system and the laboratory results showed insignificantly differenced in the effect of this pH controller and ferric sulphate, the last one was chosen to be used industrially. Furthermore, ferric sulphate is a reagent already used in the industrial plant due to the coagulant effect. So, solids particles disposed in the tailings dam will present a higher coagulation and the effluent leaving the dam is expected to present lower solids content, which means, lower environmental effect.

4 CONCLUSION

Froth control is an issue that must not be overlooked in industrial iron ore concentrators, since could lead to operational instability and usually is caused by amine addition, which is vital for ore concentration. A simple laboratory procedure was tested to attest that pH control plays a significant role in froth stabilization of slurry tailings produced by iron ore concentrators, since the amine concentration does not surpass typical values. The addition of ferric sulphate solution leaded to froth decrease in the industrial tailing, which improved pumping capacity.

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