VARGEM GRANDE PLANT FLOTATION PROCESS OPTIMIZATION: IFLOT SYSTEM[1]

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Abstract

This work started in the year 2005 when the possibility of using intelligent systems for flotation control were identified. Over the course of 2005 a number of works were conducted aimed at mapping control and process variables for Vargem Grande flotation plant, as well as to identify how an intelligent automated system would control these variables. In general, this system comprises a database containing flotation operations log over a long period of time, which allowed for defining an optimized performance curve for this system, and a software developed specifically for this application to control the flotation process' instrumentation-based supervisory system in order to control the process efficacy within the optimized curve. Qualitative tests were performed in 2007 using a prototype of this system, the results of which made it possible to frame industrial scale tests in 2008 for approximately three weeks. During the tests, it was noticed that the system drastically reduces the variance and the standard deviation of mass and metallurgical recovery results. Additionally, an increased average of mass and metallurgic recovery results was observed, the flotation concentrate being kept within product's specifications. The system's weakness is that it does not immediately and assertively interfere when the ore presents and atypical behavior in relation to i-Flot database.

Key words: Flotation; Optimization; Mineral process; Simulation.

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1 INTRODUCTION

The flotation process, comprising the separation of ores by function of their affinity or aversion to the liquid phase (this affinity is acquired with the use of chemical reagents), is evaluated depending on the selectivity, that is, separation between silica and ore. The greater the silica grade on the foam and the smaller the number of ore particles, the greater the process selectivity.

The operator of an ore treatment plant takes decisions relative to the process variables in order to potentialize the separation provided by the natural flotation phenomenon. As the silica grade in the feed varies excessively, coupled with other circuit-related problems, the operator finds it difficult to keep the optimal selectivity curve for the set period. Because of that, the optimization of this process was deemed necessary.

> Mass separation using the silica flotation phenomenon with a view to ensuring a given grade of such impurity in the final ore concentrate, turns out to be a rather difficult task for plant operators, both with respect to fee grade variability and the imbalance generated by the circuit's circulating load.[(1)]

The metallurgical objective of the flotation process is to ensure maximum level of ore mass recovery with the least possible silica grade. Therefore, optimization is attained when the greatest possible selectivity level in silica flotation is reached.

Based on this assumption, the project's general goal was to develop an optimization system to allow for greater operational stability and results, maximizing the flotation process metallurgical performance.

2 MATERIALS AND METHODS

Through the use of artificial intelligence tools and by working out Vargem Grande Ore Treatment Plant log statistically it was possible to develop a software named i-Flot in order to predict silica concentrations in both the concentrate and in the waste, in addition to pointing the metallurgical location of the current operation so as to ensure the best point of the silica concentration's selectivity curve to maximize the process metallurgical performance.

This software was duly interlinked to the supervisory system that controls the processes by means of instrumentation methods. Afterwards, the i-Flot system started to capture, analyze and close metallurgical and mass balances based on available chemical results in the supervisory system, as well as by reading physical data such as column pressure, foam layer height and density. With these data i-Flot estimates the results for the next fifteen minutes of operation in terms of silica percentage and mass and metallurgical recovery. It also defines the actions to be taken based on the top limit's target value of silica grade in the concentrate and of mass recovery, maximizing either one, depending on the margin allowed by silica grade.

As an example of how i-Flot operates in practice, should silica target grade value in the concentrate be defined as a maximum of 2.0%, the system uses actual data to estimate a grade for the next 15 minutes of operation and if the grade goes down below this value the system interferes by opening the concentrate's flow valves, thus increasing the foam layer and maximizing recovery in detriment to grade. In the cases where grade is greater than or drawing near to the 2.0% target, the system interferes closing the valves, reducing the foam layer and discharging a greater quantity of waste, thus either maximizing or keeping silica grade steady in the concentrate in detriment to mass recovery.

The industrial scale test was made in January through February 2008 and albeit the duration was estimated at one month the tests were started on January 21 with the system operating every other day in order to allow us to compare i-Flot-based gains against no i-Flot- supported operations. A previous evaluation of the results was made for the period ending February 1st. As these results did not turn out very conclusive, the decision was taken to change the testing schedule to an every other week basis.

With this new schedule i-Flot was not used in the flotation operation from February 2nd through February 10th, being turned on, however, during the period beginning on February 11th through February 17th, during which a number of problems were recorded with respect to flotation and because of that the data collected during this period were disregarded. The i-Flot-supported test was prolonged and as of February 20th through February 24th it was then possible to collect i-Flot-supported flotation data.

3 RESULTS

The criteria adopted for the evaluation of the results were as follows. Flotation mass recovery, iron metallurgical recovery for the concentrate, concentrates selectivity index iron/silica in relation to feed, and the concentrate's iron beneficiation ratio in relation to feed, closed per shift over the testing period.

Balances were closed based on lab data, with data collected from the i-Flot system being disregarded.

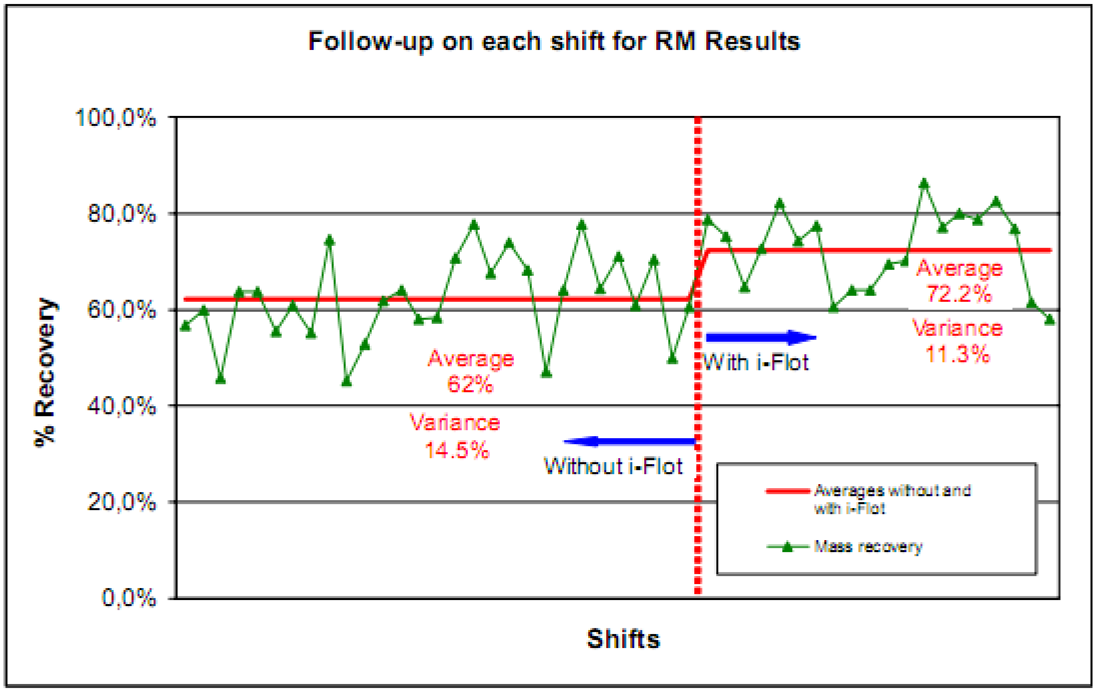

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Figure 1. Follow up on each shift for mass recovery results over the time during which the control system i-Flot was not used.

The average flotation mass recovery results with the support of i-Flot was 72.2% with an 11.3% variance (Dp/average), whereas the average flotation mass recovery results without i-Flot was 62.0%, with a 14.5% variance in results.

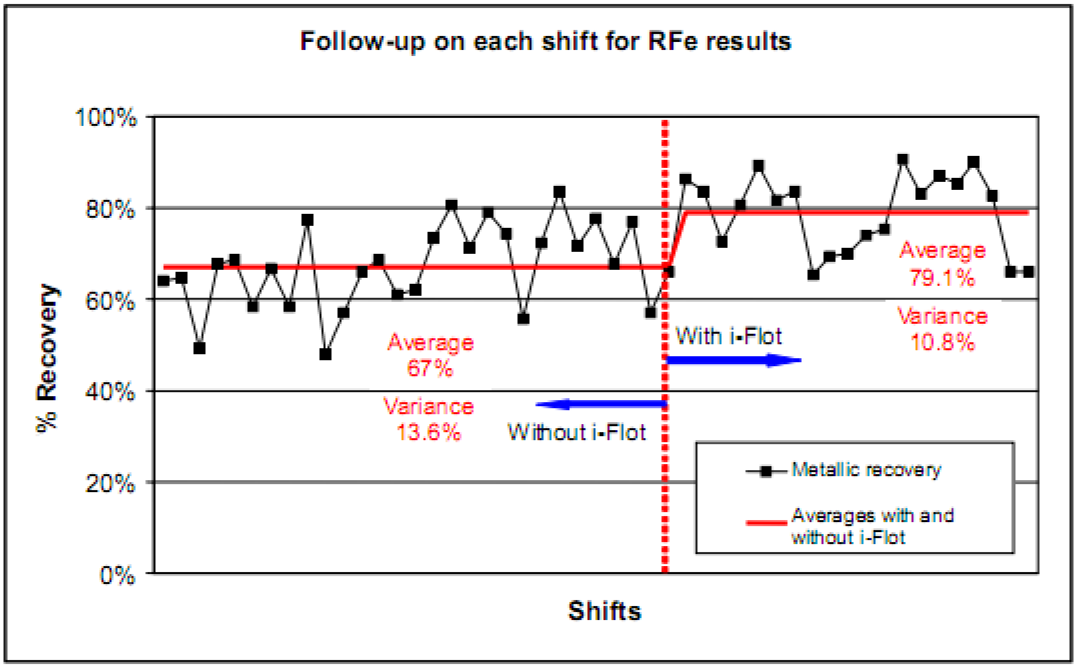

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Figure 2. Follow-up on each shift for the metallic recovery with and without i-Flot.

Figure 3 shows a correlation between silica grade in the concentrate versus silica grade in feed. The points at which i-Flot was used are less sparse in relation to the period during which i-Flot was not used.

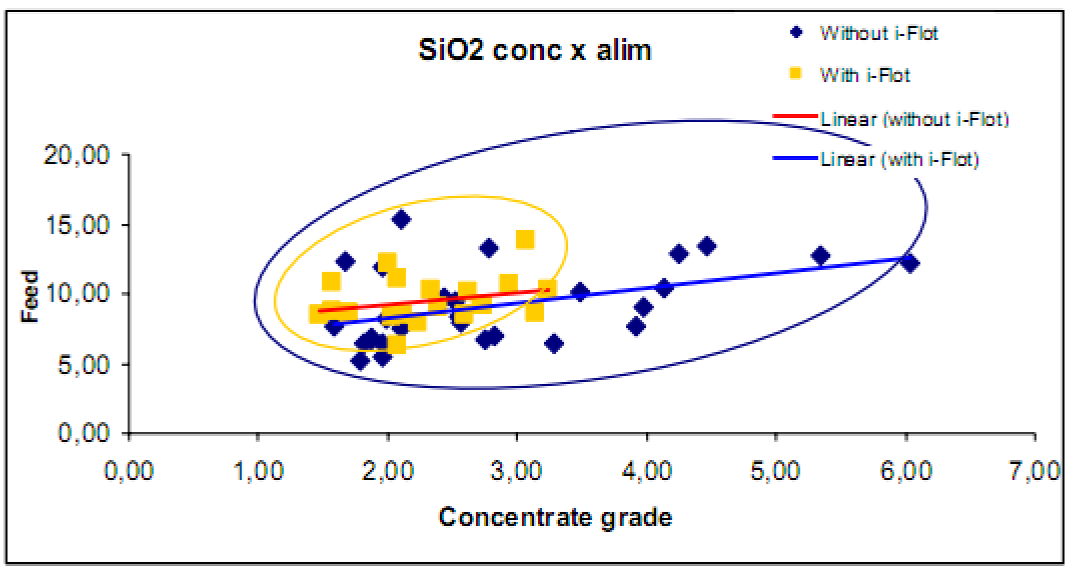

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Figure 3. Silica grade in feed versus silica grade in the concentrate with and without i-Flot system.

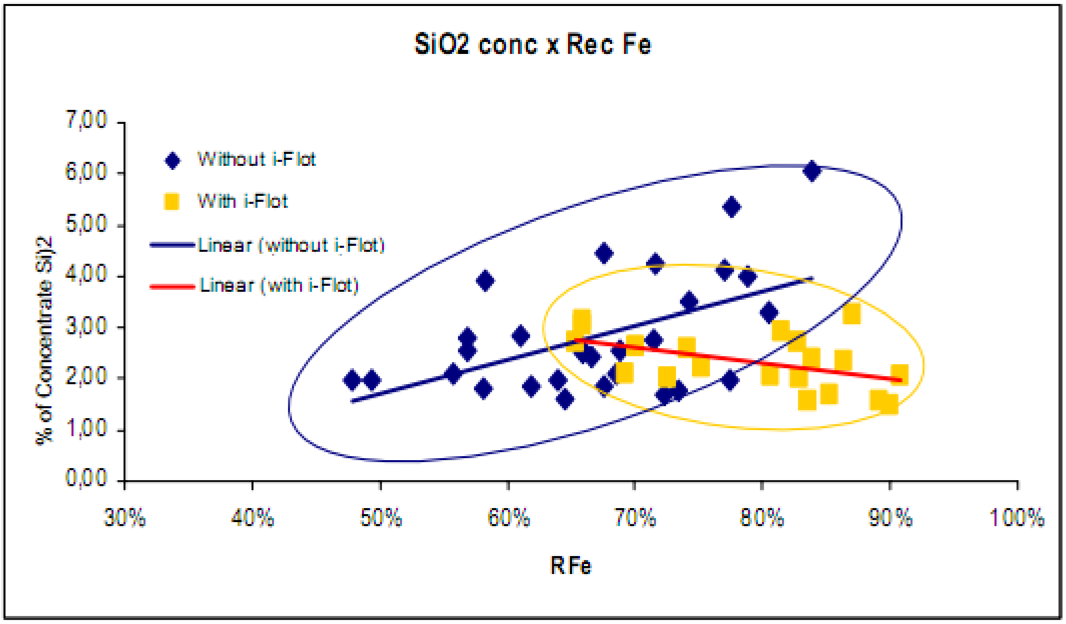

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Figure 4. Silica grade in the concentrate versus iron recovery with and without i-Flot system.

Figure 4 shows that the control system's tendency to optimize the flotation phase, concomitantly attaining low silica level results with higher recoveries. It also shows that minimal recovery levels are rather differentiated with or without the support of i-Flot.

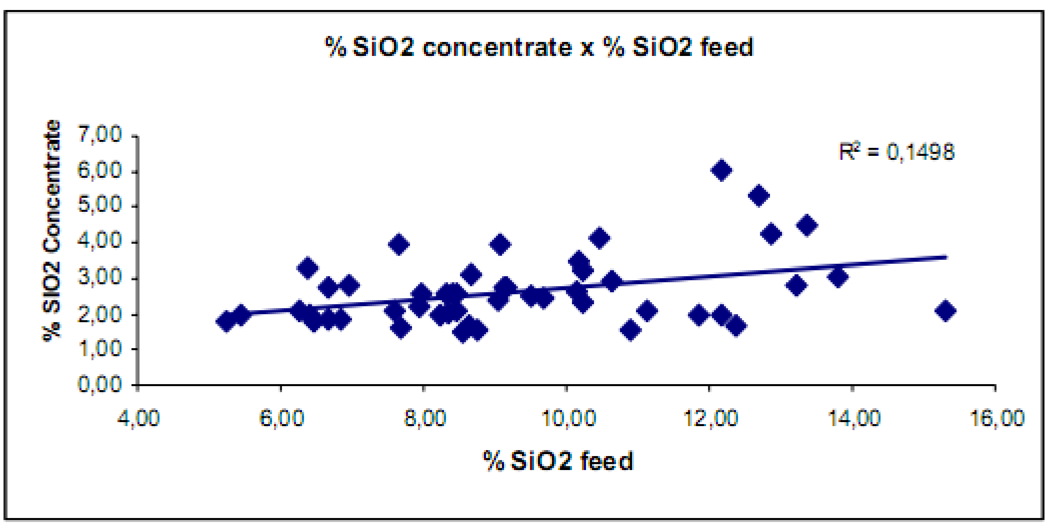

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Figure 5. Silica grade in the concentrate versus silica grade in feed.

Figure 5 shows that the correlation value between silica grade in concentrate and feed is rather low, thereby indicating that the beneficiation ratio value changes all the time. This fact alone shows that the flotation phase is being continuously changed over the course of the operation and might be undergoing optimization (which is confirmed with further analyses).

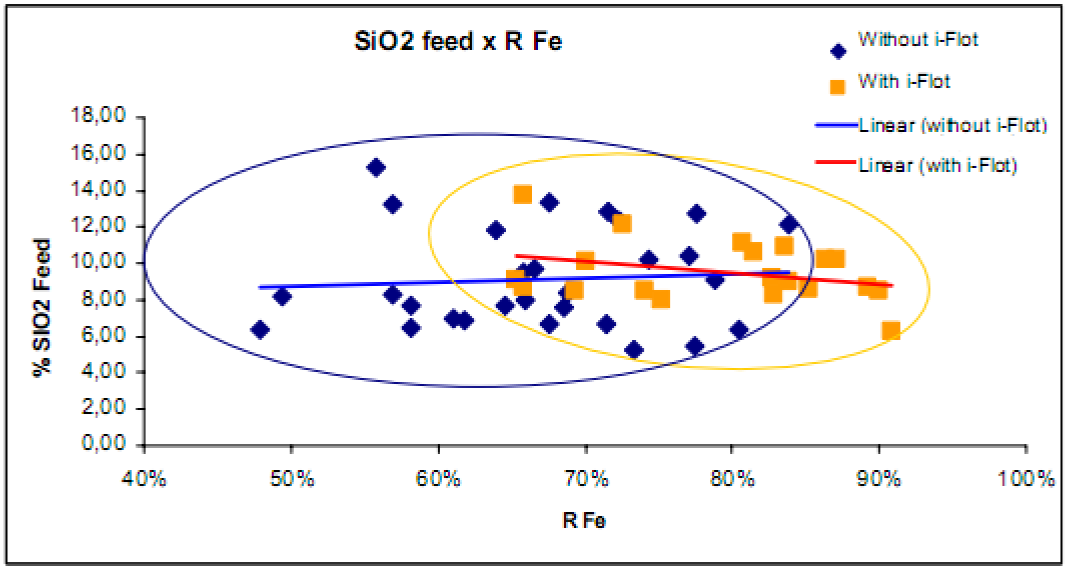

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Figure 6. Feed silica grade versus metallic recovery with and without i-Flot system.

Chart 6 shows that for an equal silica grade in the flotation system differentiated feed iron metallurgical recuperation values are obtained.

On the average, iron recovery results obtained with the support of i-Flot (65% to 90%) are greater when compared to results with no i-Flot support (48% to 85%).

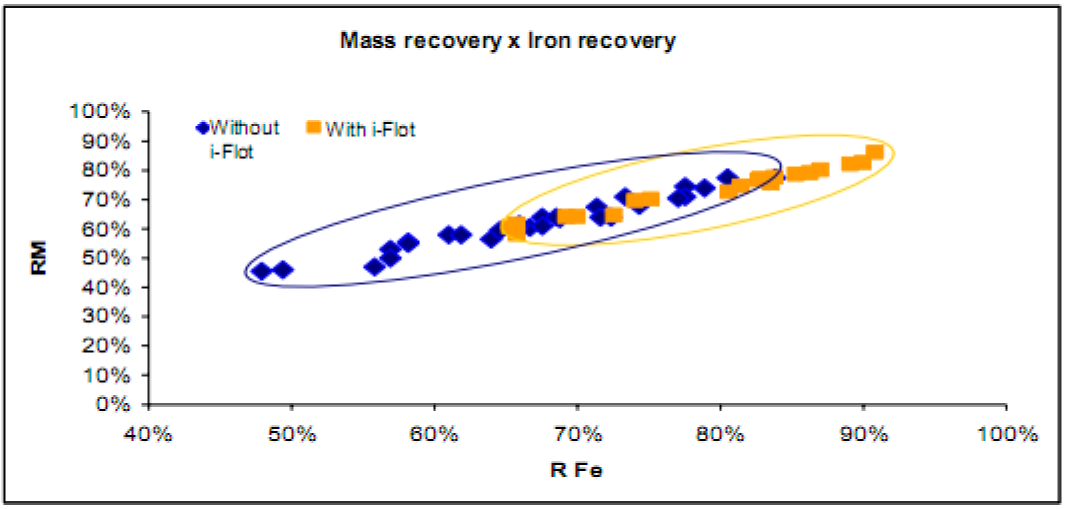

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Figure 7. Iron recovery versus mass recovery with and without i-Flot system.

The same behavior can be observed in figure 6, in terms of recovery, as in figure 7. As it has been mentioned before, the tendency of the points to form a straight line stems from the great correlation between metallurgical and mass recovery.
Dispersion in relation to the average is pretty much greater for the blue points when compared against orange points, thereby indicating a higher stability and control of the flotation process when it comes to an i-Flot-supported operation.

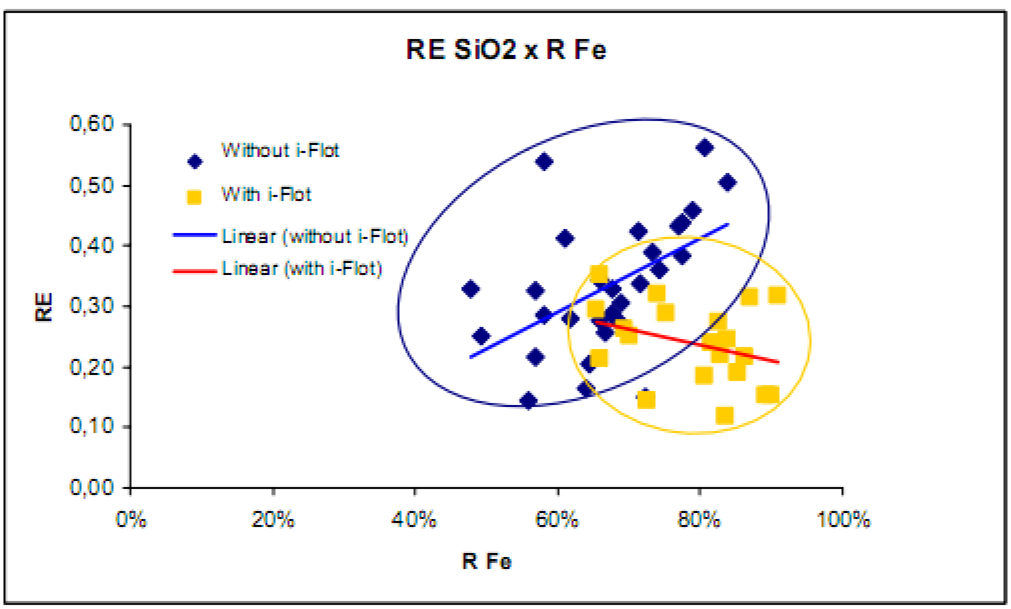

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Figure 8. Silica beneficiation ratio versus iron metallic recovery with and without i-Flot system.

Figure 8 shows that with the support of i-Flot silica grade levels in the concentrate can be reduced as demonstrated by the beneficiation ratio lower figures and furthermore associated to higher metallurgical recovery values. A smaller dispersion can once again be observed in relation to data collected without the support of i-Flot.
Figure 9 shows that the selectivity index figure remained steady at 3 all along the recovery line, and it also shows that, for the periods over which the system was used, selectivity indexes figures of roughly up to 8 were obtained, thus increasing metallic iron recovery.

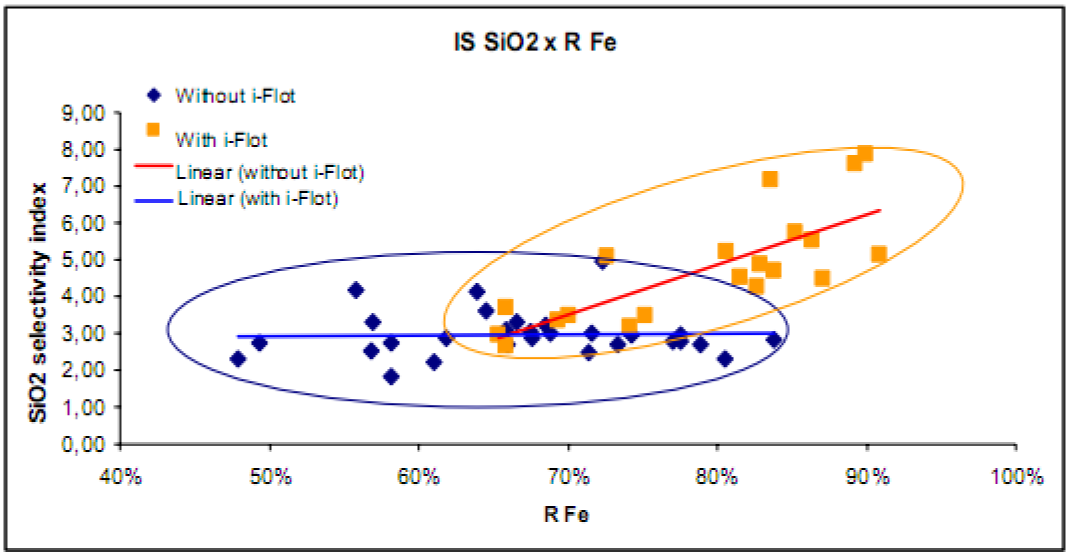

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Figure 9. Silica selectivity index versus metallic iron recovery with and without i-Flot system.

4 DISCUSSION OF RESULTS

A preliminary analysis of the results shows that the system has contributed to the flotation system with a smaller variability with respect to mass and metallurgical recovery (based on an analysis of figures 1 and 2). It became evident that the average value drifted upwards and during operations with the support of i-Flot minimal mass recovery percentage was approximately 60%, whereas an analysis of the period during which the system was not being used this minimal was roughly 45%.
As there is a high degree of correlation between mass and metallurgical iron recovery, notably, the analysis of the results for metallurgical recovery highly resembles that of mass recovery. It is therefore worth mentioning that the minimal cap for metallurgical recovery was 65% with the support of i-Flot against 45%

without the support of i-Flot during flotation operations.

It is of utmost importance to point out that even under circumstances where the levels of silica grade in the system's feed are rather high, i-Flot can keep silica grade within established standard levels. Not even once did i-Flot fail to keep silica grade levels below 3%.

It should also be noticed that without the support of i-Flot the trend is towards reducing metallurgical recovery in order to obtain lower silica grades in the concentrate.

What seems to be the case is that the system sets the silica value (e.g. 2%) and then the concentrate valves receive a command from the system to keep valves as wide open as possible to allow for recovery optimization, and when this set point drifts away from the target (which is identified by means of inside pressure values of the column and also in the correlation between this pressure and the amount of silica inside the flotation system using data from the control system's database), the control system sends a command for the valves to be closed, forcing the columns to discharge a higher volume of silica through tailings, thereby optimizing the flotation system.

In the attempt to try to understand why this did not happen without the support of i-Flot, we started by getting familiar with the grounds upon which the operator would take the decision to change the flotation system control's parameters. The only information the operator can rely on is the hourly result of silica grade levels coupled with the fact that, as we have already observed in figure 5, there is no established correlation between feed grades and silica concentrate, which makes it even more difficult to support one's decision within so short a time. The operator can only change control variables upon confirming that silica grade levels in the concentrate have exceeded its set maximum value. Only then can the operator proceed with the alterations he finds necessary, the results of which being identifiable only one hour later.

5 CONCLUSION

The i-Flot system yielded better results on the course of the testing period when compared to the period during which it was not used. The support of i-Flot allowed for an identifiable increase in the process metallurgical and mass recovery.

With the support of i-Flot, a choice between the optimization of the final concentrate SiO_2 grade versus the Fe metallic recovery optimization can be consistently and effectively established, the likelihood of which under current standard operational circumstances (with no supporting software) would be unfeasible.

As i-Flot controls neither the addition nor any specific consumption of flotation reagents, it shall be wise not to associate any consequential gain to the reduction of specific reagent consumption, but it should also be pointed out that the system guarantees a better stability of the flotation phase, and consequently reagents shall be more efficiently used.

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