OPTIMIZING CONTROL SYSTEM© FOR DESLIMING AND FLOTATION IN AN IRON ORE COLUMN FLOTATION AT THE PICO MINE[1]

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Abstract
The Optimizing Control System OCS© was implemented in the iron ore desliming and flotation at the Pico Mine in 2007, aimed at better controlling the desliming and flotation circuit, thereby attaining quantitative gains in terms of smaller process variations and a reduction in the consumption of reagents. This study introduces the operational philosophy of the System presented herein as well as the main results obtained.
Key words: Optimizing system; Flotation; Desliming; Iron

SISTEMA DE CONTROLE OTIMIZANTE© PARA DESLAMAGEM E FLOTAÇÃO EM COLUNA DE MINÉRIO DE FERRO DA MINA DO PICO

Resumo
O Sistema de Controle Otimizantes OCS© foi implantado na Deslamagem e na Flotação de minério de Ferro no ano de 2007 visando um melhor controle do circuito de deslamagem e flotação, atingindo assim ganhos quantitativos em termos de menor variação de processo e redução do consumo de reagentes.
Este trabalho apresenta a filosofia de operação do Sistema aqui apresentado, assim como os principais resultados obtidos.
Palavras-chaves: Sistema otimizante; Flotação; Deslamagem; Ferro

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1 INTRODUCTION

The OCS© complements the conventional Distributed Control Systems (DCS) or the Programmable Logic Controllers (PLC). It automatically reads information from the PLC or DSC data banks and uses a number of advanced techniques to develop new set-points.

The set points are then automatically applied to the PLC or DSC without the need for any action from the operators. These set points continually follow strategic objectives, maintaining the required quality of the product while bestowing technical and economic benefits. The OCS© architecture is shown in Figure 1.

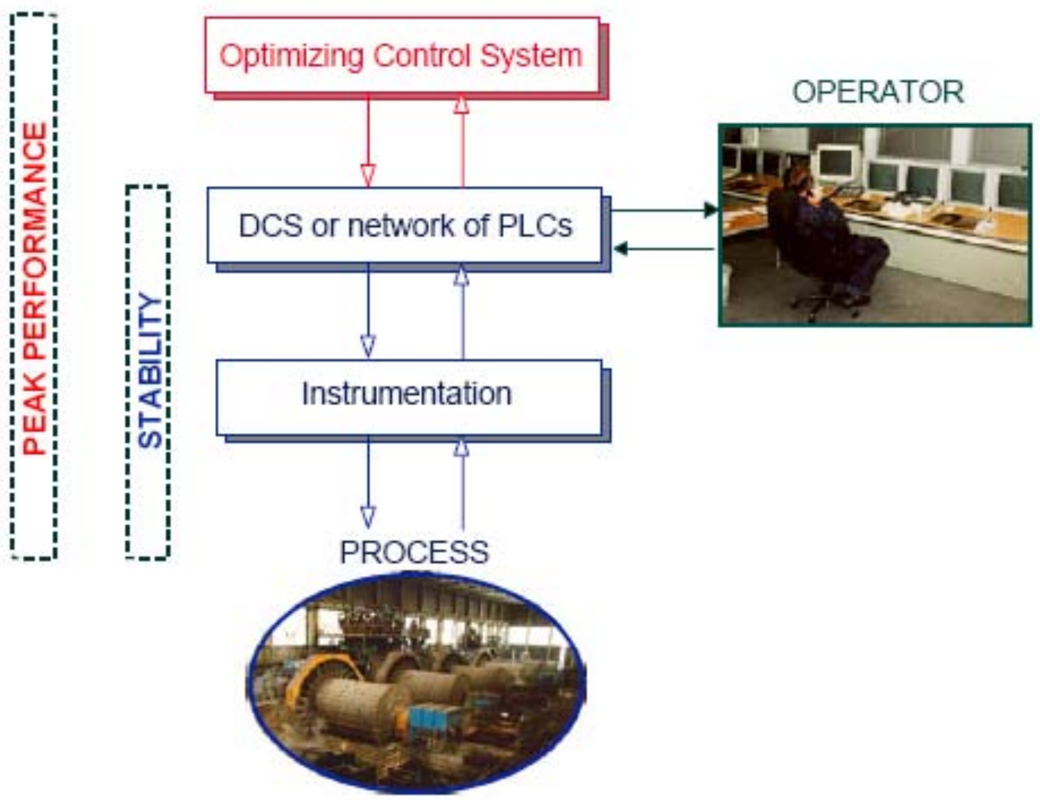

Figure 1. Architecture of a control system showing how the OCS© works.

2 MATERIALS AND METHODS

2.1 OCS© Implementation

The entire team – operators, technicians, supervisors, and engineers – actively participated in the software implementation. These are the people responsible for defining the control strategies of the process, which are done manually, and so the strategies are very realistic.

2.2 Control Strategies

The control strategies implemented in the OCS© continually adapt the set points of the process to achieve defined objectives.

The primary objectives for control of the desliming and flotation circuits are:

- Control the Al_2O_3 content of the deslimed material, which feeds the flotation;
- Control the SiO_2 content in the flotation feed and final concentrate.

The OCS© also sends messages to operators to suggest actions that could not be automatically implemented.

For the System to achieve the proposed objectives, manipulable or controllable variable are listed, which, upon being adjusted, change/control the content of the contaminants in the final desliming or flotation product.

2.2.1 Manipulable variables

The listed manipulable variables are set points of the process or controller out puts. These variables are used in the control System.

The OCS© automatically adjusts these variables or, if that isn't possible, offers recommendations so the control room operators make the actions effective. The control is initiated with the current set point values defined to give a smooth transition between manual and automatic operation. The values are automatically adjusted as follows:

When the control actions are applied to control disturbances in the process and optimize the desliming operation.

Table 1. Manipulable variables at the desliming stage

Manipulable variables	Unit	Range
Pump sump level	%	50 - 75
Cyclone pressure	kgf/cm^2	1 – 2.5

- When control actions are applied to control disturbances in the process and optimize the flotation operation.

Table 2. Manipulable variables at the flotation stage

Manipulable variables	Unit	Range
Level of slurry/froth interface	mm	600 – 1.200
Air flow rate	m^3/h	200 - 350
Amine dosage	g/t	35 - 60
Starch dosage	g/t	400 - 500

2.2.2 Controlled variables

Controlled variables are those obtained directly in the field, as a result of the change at the manipulable variable, which are observed to keep the process objectivs.

Table 3. Controlled variables

Controlled Variables	Unit
SiO_2 content in the feed	%
SiO_2 content in the final concentrate	%
Al_2O_3 content in the deslimed slurry	%
Flotation froth overflow speed	cm/s

2.3 Control Rules

The control rules are responsible for changing the controllable variable set points to maintain the process variables within the acceptable or recommended range.

Given that the main objectives are to control the Al_2O_3 content in the deslimed material that feeds the flotation, the SiO_2 content in the concentrate, and the iron content, the following control rules have been implemented.

2.3.1 Control of the Al_2O_3 content of the deslimed material

Every hour, the Al_2O_3 content of the material that feeds the flotation (deslimed slurry) is made available. By using fuzzy logic, the OCS© assesses the Al_2O_3 content, then using the targeted set point as a parameter, it concludes whether the Al_2O_3 content is very low, low, normal, high, or very high.

The graph in Figure 2 shows the assessment of the Al_2O_3 content of the deslimed material by using fuzzy logic.

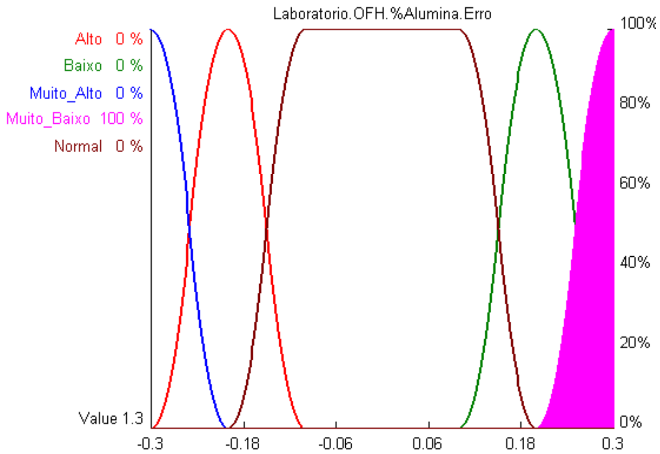

Figure 2. Assessment of Al_2O_3 content of deslimed material

To change the Al_2O_3 value of the deslimed material, the OCS© will activate the set point of the pump sump level, changing the percentage of solids in the slurry that will feed the desliming. The System makes very negative, negative, null, positive, or very positive increments in the pump sump levels.

The graph in Figure 3 illustrates the analysis performed by the software to change the pump sump levels.

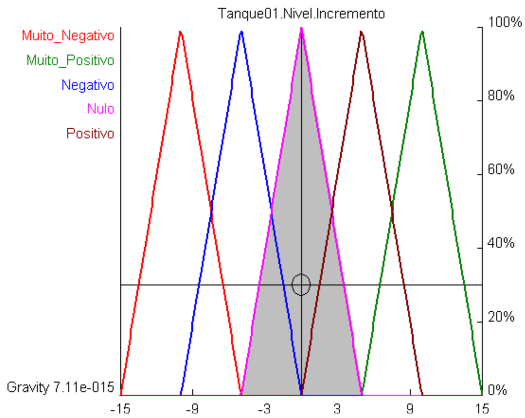

Figure 3. Changes in the pump sump level assessed by the software

2.3.2 Control of the SiO_2 content in the final concentrate

By using fuzzy logic, the OCS© assesses the SiO_2 content of the concentrate. Then, using the targeted set point as a parameter, it concludes whether the SiO_2 content is low, normal, or high.

The graph in Figure 4 illustrates the verification of the SiO_2 content of the concentrate.

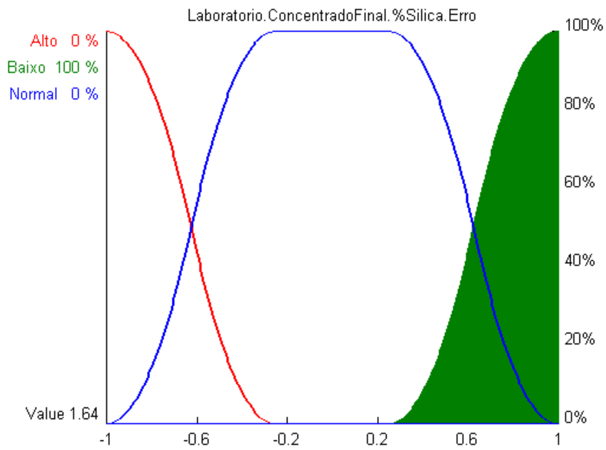

Figure 4. Verification of the SiO_2 content in the pellet feed

The SiO_2 content of the concentrate can be controlled through the variation of the set point relating to the foam overflow speed and by changing the set points relating to adding starch and amine reagents.

- Variation of the overflow speed set point:

The OCS© activates the overflow speed set point, using fuzzy logic to make very negative, negative, null, or positive increments.

The graph in Figure 5 shows the completion of the fuzzy logic for changing the overflow speed.

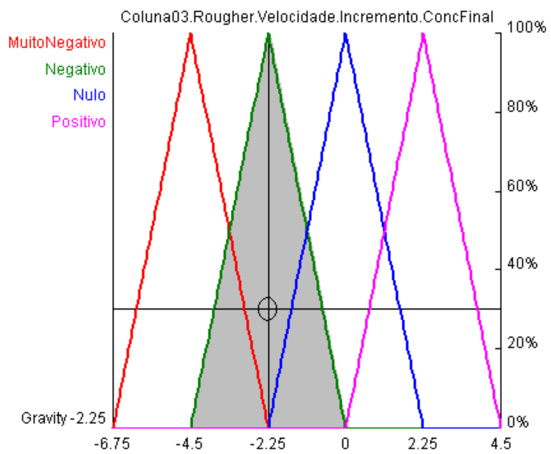

Figure 5. Completion of the fuzzy logic for changing the overflow speed

- Manipulation of the set points for adding starch and amine reagents:

The OCS© activates the set points relating to adding the amine and starch reagents, making negative, null, or positive increments to the reagent dosage. The activation is made in the following manner:

1. If the SiO_2 content in the feed is high, then the amine dosage shall be increased and the starch dosage shall be reduced, or vice versa.

2. If the SiO_2 content of the concentrate is high, then the amine dosage shall be increased and the starch dosage shall be reduced, or vice versa.

2.4 Assessment of Results

For the purpose of assessing the results, the plant's control system data were analyzed every two minutes with and without the OCS© controlling the plant. That way, comparative graphs of both situations could be created, taking a broad range of data into account. In this case, data from November 2007 through May 2008 were analyzed.

3 RESULTS AND DISCUSSION

A significant increase was observed in the OCS© operating time throughout the analysis period, as can be seen in the Figure 6. It is interesting to note that in the first two months, the control was mostly performed by the operators themselves. In the following two months, the plant operated approximately half the time in each mode and, in the final two months, the plant was operated largely with the OCS©.

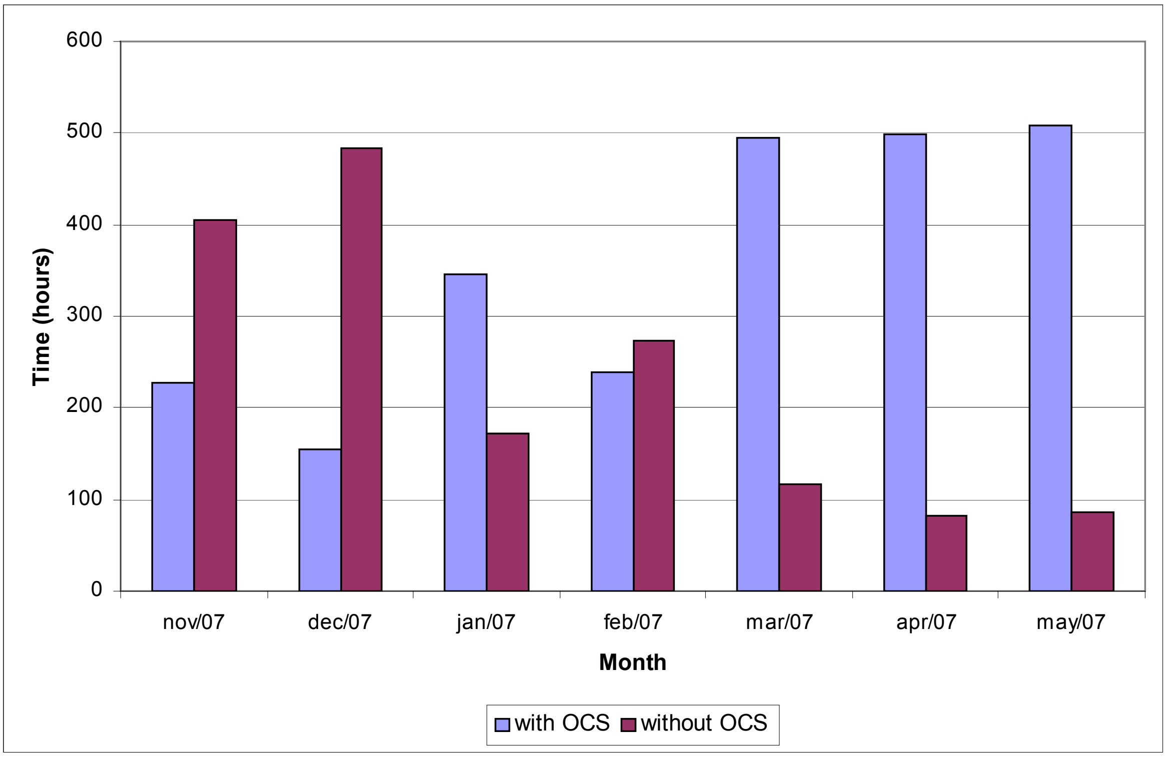

Figure 6. Plant control time with OCS©

From the above data it can be seen that during the first four months of operation, the System was already being used almost continuously. This high level of use is due to the manner in which the implementation was made, with participation from all of the involved parties and quick resolution of the small problems that could have interfered with the use of the System.

Another interesting point that was observed was a small increase of the flotation feed rate with the System, as can be seen in the Figure 7.

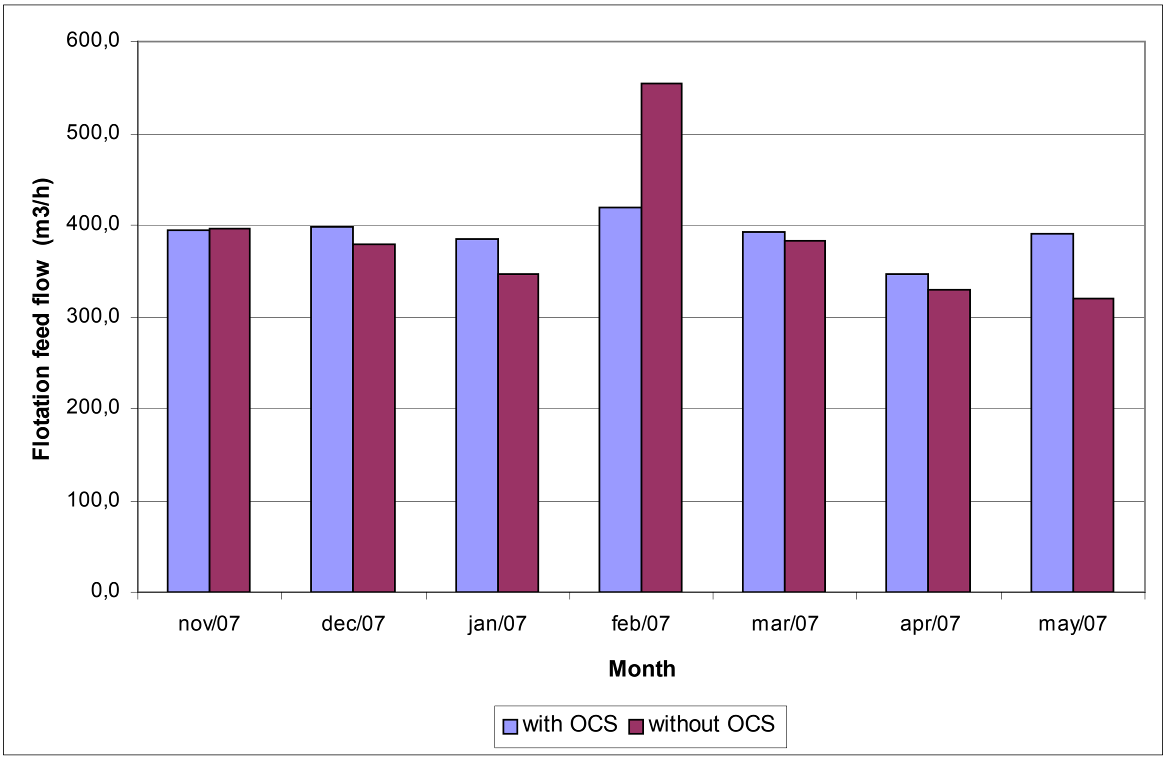

Figure 7. Flotation feed flow

It was understood that this increase was possible because the System always looks for the higher rate by smoothly changing the flotation feed, thereby maintaining a higher rate without impairing the quality of the products.

There was also a significant reduction in the standard deviation of all variables manipulated by the System. Figures 8 and 9 illustrates some of these variables.

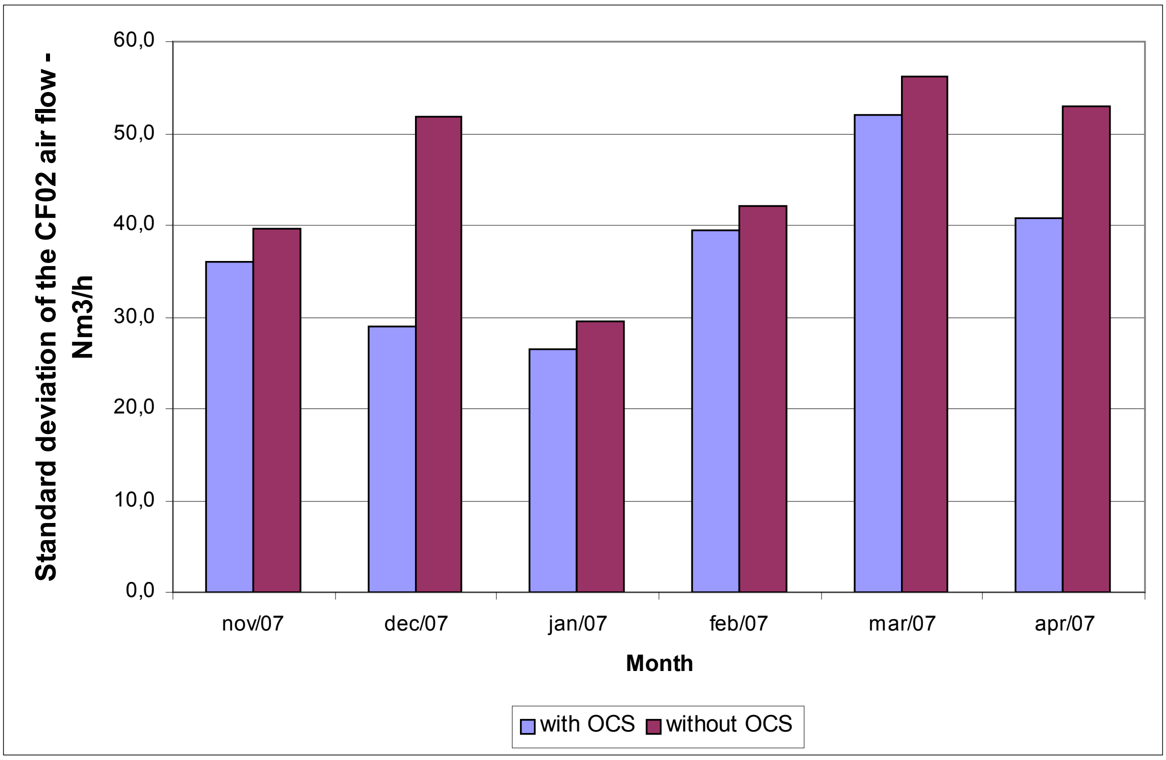

Figure 8. Standard deviation of the CF02 air flow

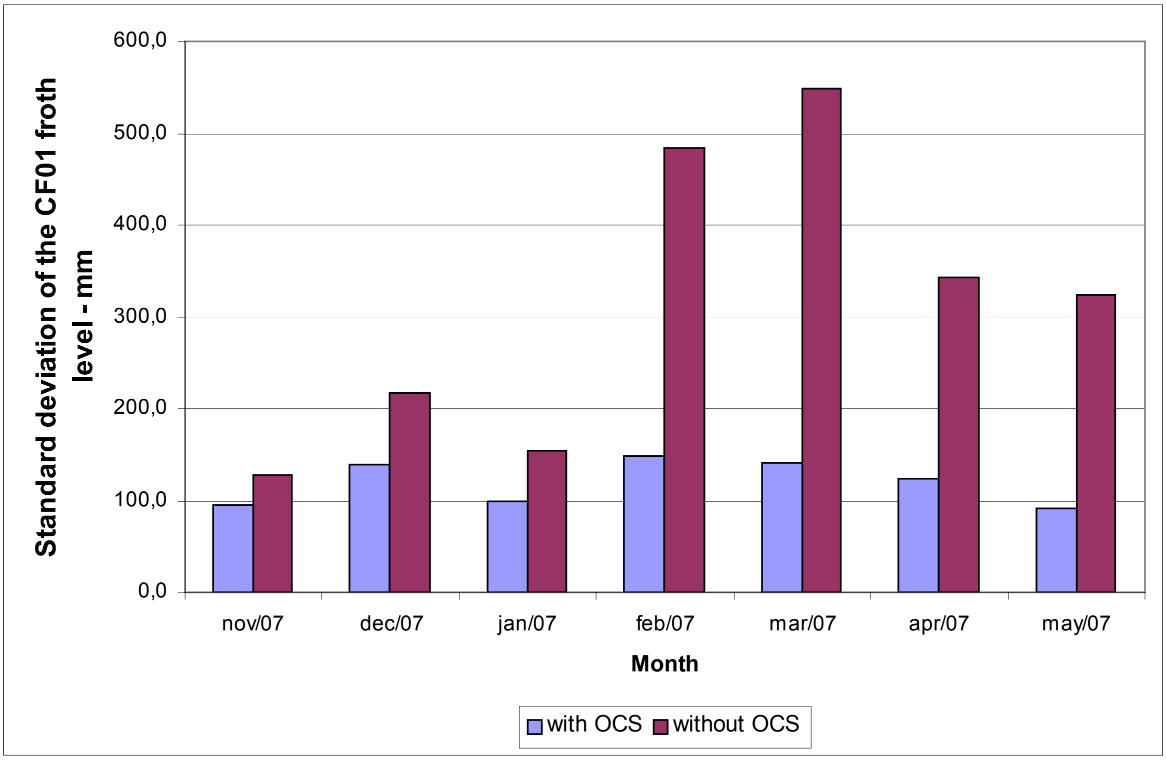

Figure 9. Standard deviation of the CF01 froth level

This clearly shows that the System effectively controls desliming and flotation in the smoothest manner, thereby causing fewer oscillations.

Other interesting effect resulting from the greater stability of the process is the reduction in the overflow time of the pumps sump. As the circuit oscillations are smaller, the pumps operate in a more stable manner. Figure 10 illustrates this point.

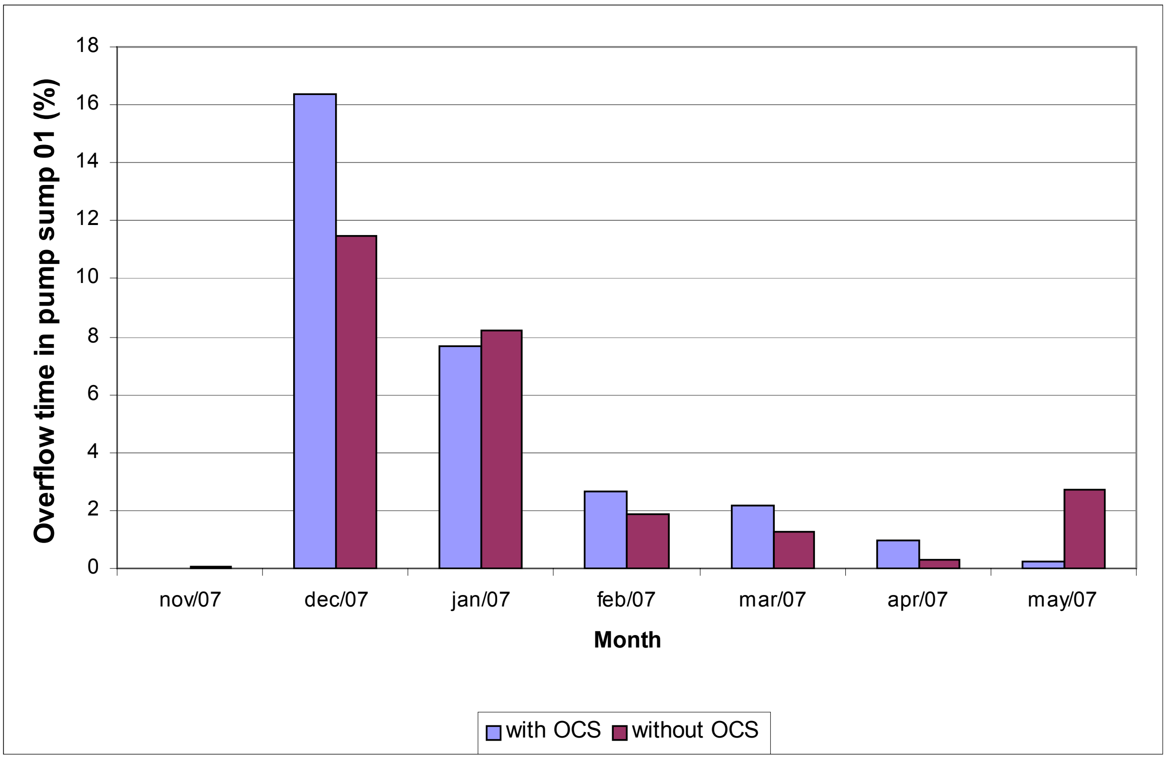

Figure 10. Overflow time in pump sump 01

Starch consumption remained constant while the OCS© was operating, whereas there was a 5% drop in amine consumption, as can be seen in the Figure 11.

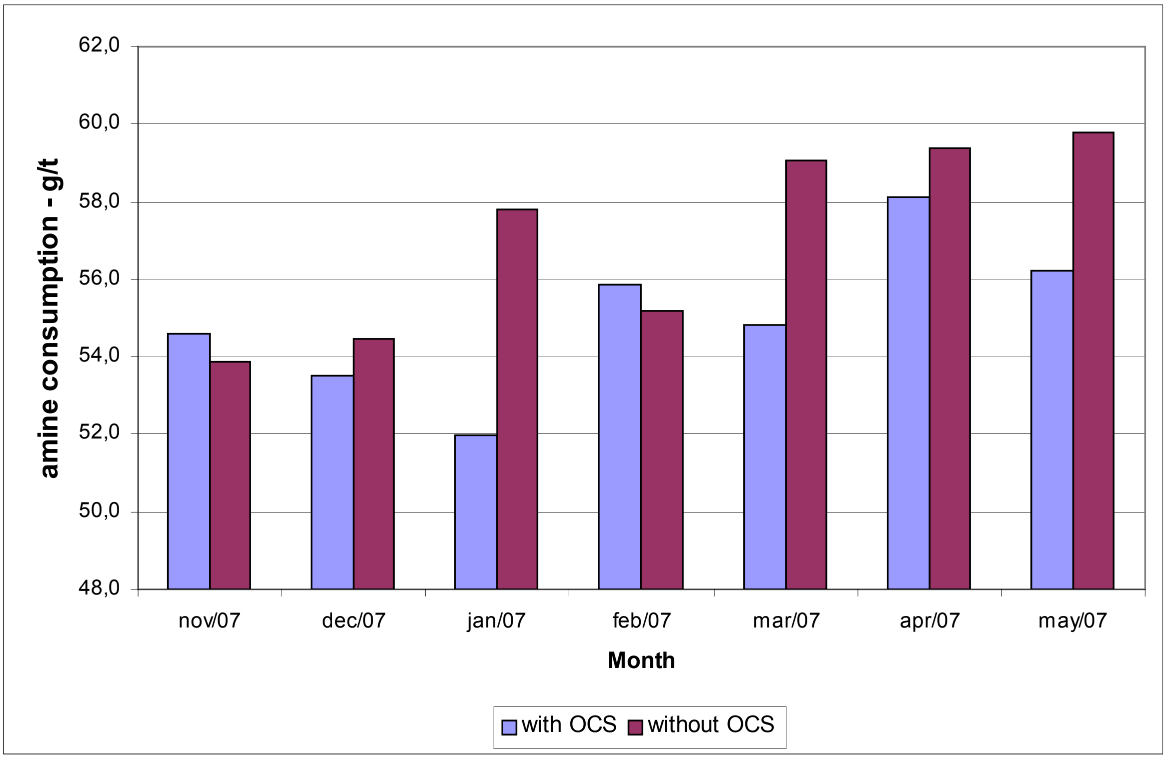

Figure 11. Amine consumption

In terms of quality, the results were similar with and without the OCS©. However, in the final two months of analysis, when the OCS© was operating almost 100% of the time, the silica content of the flotation feed was significantly higher than in the previous months. Therefore, the fact that the quality had been maintained shows an important gain with the OCS©.

A non-measurable piece of data should also be mentioned, which is a reduction in the control room technician's workload, who can now use the time that was once spent controlling levels, air flow, and reagents to analyze the process in a more detailed manner, thus contributing to the early identification of possible deviations in the process.

4 CONCLUSION

Based on the assessed data, it can be stated that the installation of the specialist System brought significant gains to the Pico Mine's desliming and flotation circuits. A small increase in the flotation feed rate and a reduction in the variability of the manipulable variables with greater stability in the process were observed. Lastly, amine consumption was reduced by approximately 5%.

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