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Barometric Column Filtration v/s Filtrate Pump Filtration Comparison: Case Study

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ABSTRACT

The filtering of sandy tailings from the reverse cationic flotation processes and the subsequent stacking of these tailings has shown to be a very strong trend in Brazilian iron ore mining, especially after accidents involving geotechnical structures known as tailings dams, but also due to concern of mining companies to develop a disposal technique that is more complacent with the environment and the surrounding society.

In order to develop the sandy tailings filtration project, a fundamental requirement was the correct choice of filtration technology among the many existing ones. For the material object of this study, the filter with vertical discs presented itself as the most productive due to factors such as granulometry, specific surface of the material and the humidity required in the filtration product. Several exploratory and material characterization tests were carried out for this purpose.

Disc filters have the principle of operation linked to the difference in atmospheric pressure and the vacuum pressure induced by pumps. The vacuum must act on the filtering screens next to the filter heads and, in order not to drop the yield, the system must be sealed hydraulically.

As previously mentioned, there are basically two ways to hydraulic seal the system. The first and most common in Brazilian iron ore filtration is carried out through barometric columns and the other is using filtrate pumps installed directly in the vacuum receiver of the filtration facilities. The decision of which method to use has major implications for the design of the filtering installation and the comparison between the two conditions mentioned is the objective of the present work.

INTRODUCTION

Disk filtering operation

Filtration using vertical disc filters uses the pressure differential to perform the filtration process. For this purpose, vacuum pumps with a liquid ring are used to induce the vacuum to the filter head. In this head, there is a device known as a flange or rotary valve whose function is to regulate the filtering time allowing the vacuum to act during the periods destined for the formation and drying of the material. During these periods, the difference between atmospheric pressure and the induced vacuum causes the mineral particles to be attracted to the filter mesh fixed on the discs forming the so-called cake.

In the process of forming the cake, a large amount of water and fine solids is carried over in the form of a flow known as filtrate. Under no circumstances should the filtrate flow into the vacuum pump, for this purpose, devices known as separating vessels are installed. The purpose of this feature is to create a volume expansion point that provides a reduction in the flow speed and provides the necessary conditions to allow the separation of the air flow from the vacuum induction and of the water and fine solids dragged together.

Water and fine solids due to density difference are directed to the bottom of the vessel while the air flow is directed to the vacuum pump through ducts at the top of the separating vessel. To remove the flow of water from inside the vessel without creating undesirable points of vacuum induction, barometric columns dimensioned in order to prevent the vacuum pump from receiving water keeping the system watertight are used. Another way is to use filtrate pumps installed directly in the vacuum receiver. See schematic figure below:

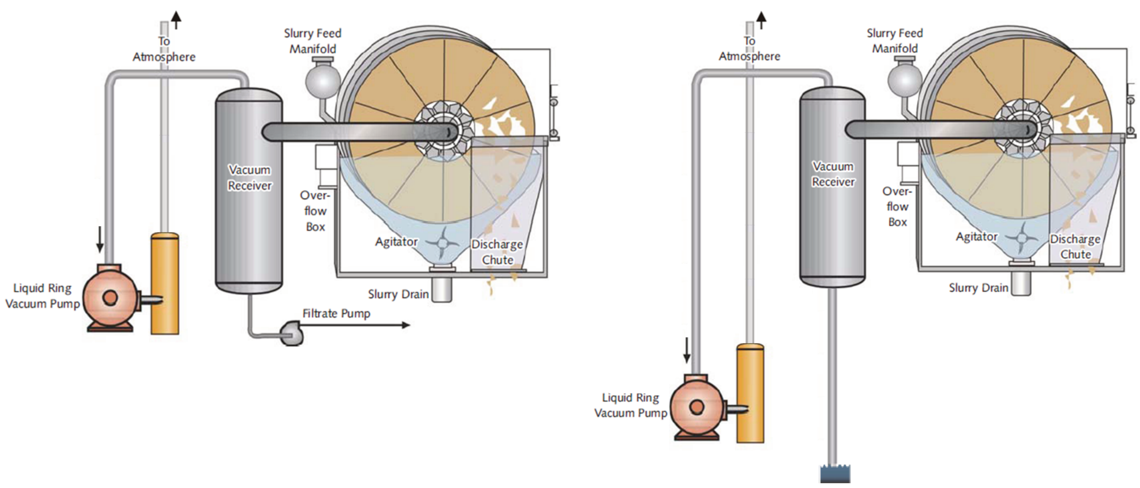

Figure 1 Comparative scheme between filtration with barometric column and filtrate pump

Project Characteristics

The sandy tailings filtration was designed to filter the material generated by the reverse cationic flotation processes in the iron ore plant. To this end, several characterization tests were performed on samples collected in the plant, in order to determine the material characteristics and the unit filtration rate. Below are the characteristics of the chemical test performed.

Table 1 Average data from chemical tests performed on samples

Sample	Fe	SIO_2	P	AL_2O_3	Mn	TiO_2	CaO	MgO	PPC	Density
Average	12.38	81.19	0.009	0.15	0.001	0.008	0.007	0.059	0.14	2.90

To evaluate the best filtering condition, exploratory tests were performed on the samples to determine the type of filter mesh to be used. For that, tests of the type "leaf tests" were carried out considering the maximum cycles of formation and drying in 11.0 and 45.0% in the configuration of the filter heads. The following table shows the average leaf test results for the tested fabrics, varying the formation times and consequently the thickness of the cakes.

Table 2 Average data from leaf test for filter mesh pre-selection

Filter mesh	Solids (%)	pH	Moisture (%)	TUF ($t/h/m^2$)	Thickness (mm)	Rotation (rpm)	Cycle (s)	Formation (s)	Dry (s)
Valmet PT2031SK	65.0	7.0	12.32	2.086	40.0	0.8	80.0	6.0	36.0
Valmet B2520 V1	65.0	7.0	13.51	1.595	30.0	0.8	80.0	4.0	36.0

After performing the leaf test, pilot tests were carried out to validate the application and selection of the filter mesh, in addition to the vacuum pressure to be adopted. Table 3 below shows the results obtained with the pilot tests in addition to a comparison with the laboratory data and figure 2 shows a sequence of images of the filtering process during the performance of the pilot tests.

Table 3 Data obtained from pilot tests

Test	Sampling	Solids (%)	Fomation (%)	Drying (%)	Thickness (mm)	Moisture (%)	TUF (t/h/m²)
	Start				52	14.87	3.43
Pilot Test	Middle (After 2 hours)	65.0	10	30	43	14.56	2.75
	End (After 4,8 hours)				34	13.95	2.30
Leaf Test		65.0	10	30	45	15.61	3.20

Figure 2 Vacuum gauge and filter head characteristics

After the conclusion of the tests, the equipment was dimensioned for operation on an industrial scale. For this, a unitary filtration rate of 2.10 t / h / m² was adopted due to the tendency to reduce the permeability seen during the tests. Therefore, the filtering dimension was adopted as shown in table 4 below:

Table 4 Specification of tailings filtration equipment

Nominal Rate (t/h)	Design factor	Project Rate (t/h)	Equipment	TUF (t/hxm²)	Calculated Equipment	Adopted Equipment
1 323	1.2	1 632	8'10" – 14 disc	2.10	6 units	8 units

Evaluation of the barometric column

Specification criteria

Due to the principle of operation of the hydraulic sealing by barometric column, the reduction in the total height of the filtering building was not viable, since for such an application, the height of the column must guarantee the sealing and avoid the induction of vacuum at undesirable points. In practice, the dimensioning of barometric legs follows a conservative criterion given by the following equation:

$$H = 1{,}2 \times P_{ATM} \tag{1}$$

In addition, the hydraulic sealing tank of the barometric column installed at the bottom of the installation, must follow a simple criterion to guarantee the sealing of the system. It should also be noted that the barometric column should preferably follow in a linear manner from the vacuum reviever to the sealing tank to prevent clogging, dragging of solids, among others. Figure 3 below shows the two conditions described:

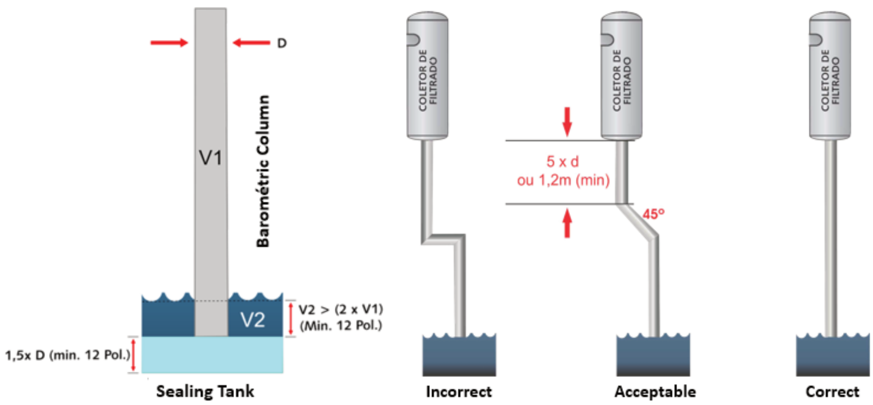

Figure 3 Specification criteria for the sealing tank and barometric columns

Filtrate pump rating

Table 5 Data used to specify filtrate pumps

Pump Type	Nominal Flow (m³/h)	Project Flow (m³/h)	Equipment	Discharge Pressure (bar)	Power (kW)	Adopted Equipment
Centrifugal	60.5	90.75	Krogh 4”x 9”	2.10	11.0	8 units

RESULTS AND DISCUSSION

Mechanical arrangement evaluation

The installations' arrangements showed significant variations in total height. In plant, however, they did not show significant changes since the filters have the same dimensions. The slurry distributors for the filters were installed in independent structures in the case of filtration with filtrate pumps (option 01) and integrated into the building in the case of barometric columns (option 02). This definition is due to the relative height of the structure. The vacuum receiver for option 02 were installed at the filter level, with 2 vessels for each filter. In option 01, the pots were installed on the floor, however, as there was only 1 vacuum receiver pot per filter, the dimensions were larger. Figure 5 below shows the general comparison of the arrangements:

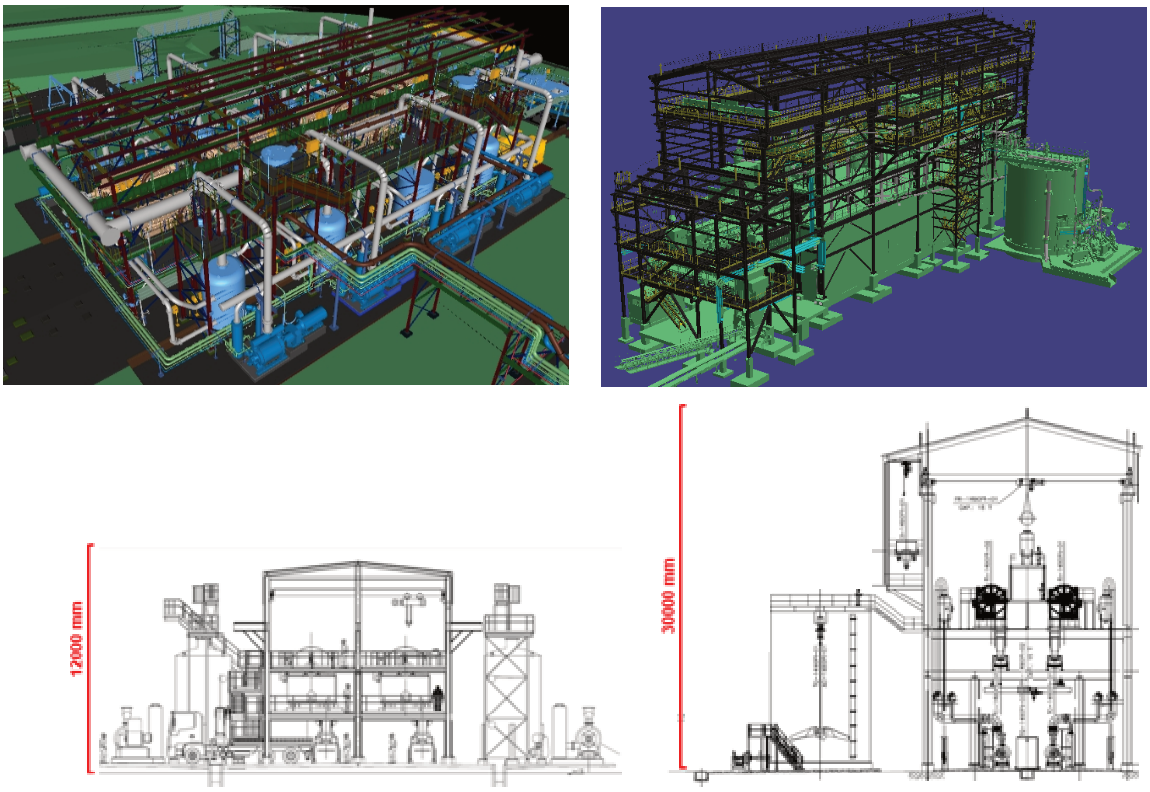

Figure 5 Comparison between mechanical arrangements - Left (option 01) Right (option 02)

Evaluation of metallic structures

The metallic structures of both options were verified in order to have a minimum use of 85% of the resistance of the main structural profiles. The dimensioning was performed following the premises established in the NBR 8800 standard. Due to the difference in height of the installations, a weight of the structure was expected in option 01. Figure 6 below shows the comparison between the structures of the two options evaluated below, table 6 presents the comparison between the total weight of the structures for the two options.

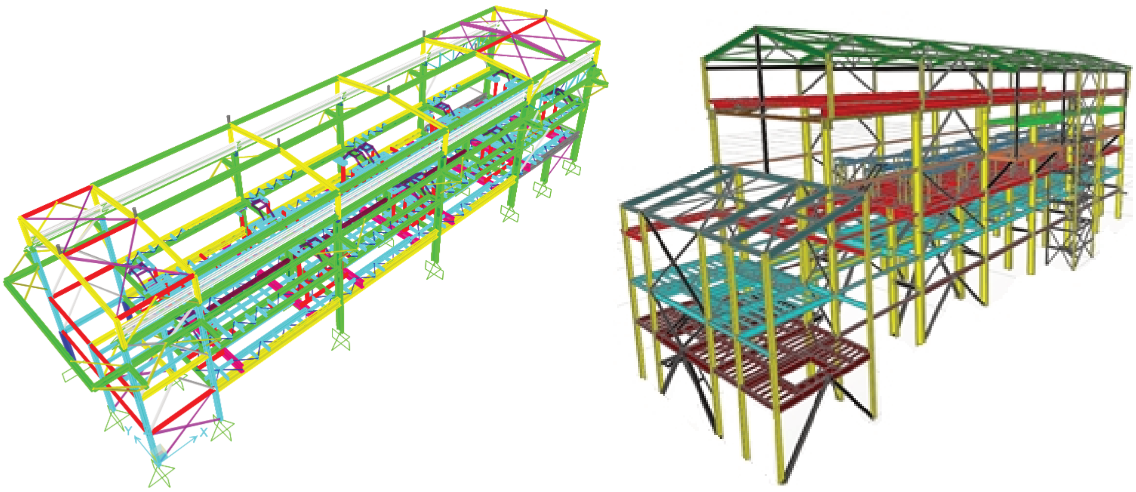

Figure 6 Structural comparison - Left (option 01) Right (option 02)

Table 2 Comparison between the weight of the structures

Option	Description	Structure weight (t)	Cover tiles (m^2)
01	With filtrate pump	268	831
02	With Barometric Column	600	3 897

Evaluation of Energy Consumption

The difference in energy consumption between the filtrations occurs due to the difference in level for supplying the filters and the need to install filtrate pumps. The figure above showed that the influence of filtrate pumps on total filtration consumption represents only 1.0%, while the energy required by filtration feed pumps to pump with a greater geometric difference has a greater influence on total consumption reaching 5, 0% of consumption.

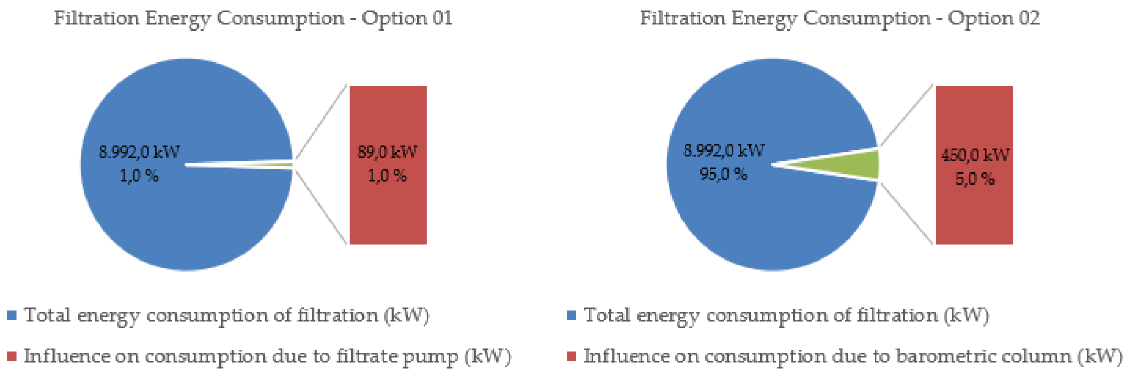

Figure 7 Comparison between energy consumption

CONCLUSION

After making the comparisons, it was found that the reduction in the dimensions of filtration with the use of filtrate pumps was the most attractive option, since the smaller dimensions of the building also led to lighter structures with a reduction of approximately 45.0% of total weight. This consideration could also be accounted for the civil foundations of filtration, however, due to the difference in the requesting efforts, it was possible to adopt another construction method for the filtration of option 01.

Energy consumption could be a major factor against option 01, however, as shown, the condition is reversed, that is, the consumption of filtrate pumps was less than the consumption required to pump at a higher elevation for the case of option 02. However, it is worth noting that this article did not deal with items such as wear parts, equipment maintenance, among others that would be unfavorable indications for option 01.

Therefore, after the studies presented, option 01 with filtrate pump was selected for the tailings filtration project. Figure 8 below shows the construction status of the installation

Figure 8 Construction status of Tailings Filtering