High Pressure Filters for Iron Ore Tailings

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ABSTRACT

This study aims to analyses the use of high-pressure filter presses in the dewatering of slurry resulting from mineral processing, especially iron ore mining tailings and slimes.

The current practice problems of deposition of fines in tailing dams were analyzed, as well as the new challenges faced by the sector in relation to water scarcity and energy efficiency. Are listed technological differentials implemented in Matec filter presses and analyzed the benefits in application of this technology, such as higher water recovery, reduce of environmental impacts and reduce of operating costs for handling and disposal of waste. Lastly, we analyze the filtration tests performed on iron ore tailings and slimes and a case study.

INTRODUCTION

Mineral processing is mostly done by wet processes. Water is used at different stages of classification, concentration, grinding and transportation of ores, without which such processes would become inefficient, expensive, or even impossible to be performed according to Chaves (2013)[1]. After the processing stage, a waste stream containing water and non-commercial materials needs to be addressed: mining tailings.

According to Guimarães (2011)[2], the increase of waste volume generated in mining activities, driven by the crescent exploitation of deposits with lower metal content, has stressed the need for increasing dams to contain the waste. Generation of mining tailings increases 10 times each 30 years, according to Andrew Robertson (2011)[3].

Figure 1 – Tailings dam.

Mariana's 2015 and Brumadinho's 2019 disasters in Brazil, among others, brought a new focus to mining tailings disposal. The collapse of those tailing dams released millions of cubic meters of sludge, killed hundreds of people, destroyed villages, and caused immeasurable damage to the nature. It raised questions about the safety of dams, leading to greater difficulties in the licensing of areas for construction of new dams, associate with growing public pressure and increasing proximity to residential areas.

Figure 2 – Fundão dam's collapse.

The storage of mine tailings by means of tailings dams pose both physical and geochemical risks that must be managed throughout the life of the facility, from design and construction, through to the closure of the mine and beyond.

Now with new rules and regulations coming into play in the operation and up keeping of tailings dams, it has become more and more of a necessity to find and implement alternative solutions to better manage tailings produced within the mining sector. A regulation that has come about due to the environmental concerns revolving around tailings dams and the challenges in safely managing such dams.

The risk associated with tailings dams has been well demonstrated by recent failures resulting in significant harm to people and the environment. These incidents are not confined to any continent nor site. Tailings dam failures have been recorded at sites owned and operated by well-known groups, even at their highest level of management standards.

This has led the industry to reconsider alternative solutions for tailings, including dewatering of tailings prior to deposition (e.g. thickened and filtered) as well as different filtration technologies.

High-pressure filtration technology has been introduced and has now become the favorable technology since high-pressure filtration drives higher performance in terms of cake dryness, increased throughput, lower capital cost, and lower operational cost even for difficult materials such as ultra-fine and materials with the presence of clay. This paper aims to demonstrate that high-pressure technology is the solution for the obsolete tailing dams.

METHODOLOGY

Matec System

Matec filtration systems are usually composed of:

- Dirty water tank: receives the tailings and slimes from beneficiation plant, and conditions it to be subsequently pumped to the thickener.
- Submersible pump: lifts the slurry present on dirty water tank to the thickener.
- Matec Deep Cone Thickener: combining the thickening and clarifying functions, it delivers an underflow with 50% to 65% solids and a fairly clarified overflow. It requires a relatively small area to install and has no moving parts inside. No motors, rake, bearings, or extraction pumps.
- Bifloc + Doson: Automatic dosing, preparation, and flocculant analysis station. It mixes the polymer powder with water, makes tube tests and automatically adjusts the dosing of flocculant into thickener.
- Homogenizer tank: Receives the underflow slurry from thickener and keeps it homogeneously until its injection into the filter press.
- High pressure centrifuge pump: Extracts the dense pulp from homogenizer tank and pressurizes it into the filter. It is controlled by a variable-frequency drive.
- Matec Filter Press: After the plates closing by a hydraulic piston, the pulp is pumped into the filter, filling all the chambers formed by the union of the plates. Pressure forces the filtrate through the cloths and the drainage ducts, while the solids remain retained. After the cycle is finished, feed pump stops, and the plates are opened to discharge the cakes.

Exclusive Technologies of Matec filter presses:

- HPT High Pressure Technology®: Matec filter presses work at high pressures (16 to 21 bar - 1,6 to 2,1 MPa), ensuring maximum water recovery, minimum moisture on cakes and lower cycle time. The following figures shows the effect of pressure on dehydration (Figure 1) and cycle time (Figure 2) for a given material.

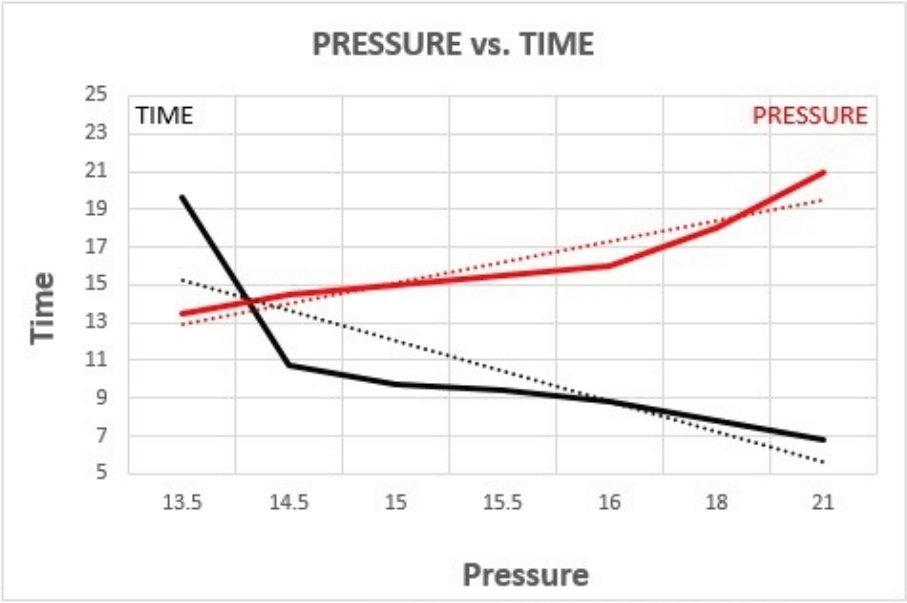


Figure 3 – Pressure effect on cake dehydration and cycle time.
Source: Matec, 2012[4].

- TT2 Fast Opening®: filter plates fast opening system, that ensures lower dead time between cycles, lower overall cycle time and consequently more productivity.

The systems are totally automated, controlled by PLC and easily integrated to existing plant.

Pilot Plant

To verify the results of iron ore tailings and slimes filtration, tests were conducted with a pilot plant filter press consisting of:

- Double diaphragm pump M4x2 with nominal air feed of 8 bar (0,8 MPa) and nominal output pressure of 16 bar (1,6 MPa).
- Matec filter press 250/3 (03 plates of 250 x 250 mm), 1,6 Mpa nominal operating pressure, 35 mm chamber thickness. Polyamide filtration cloths RS 12/12 with 500 l/min/dm^2 permeability.

The thickened pulp is placed into a homogenizer tank that keeps the solid particles in suspension. The pump suctions this pulp and pumps into the filter press, that retains the solid particles forming the cakes, and drains the recovered water (filtrate) through drainage pipes.

For results evaluation, the following measures were taken:

- filtration cycle time
- cakes moisture
- solids percentage on filtrate

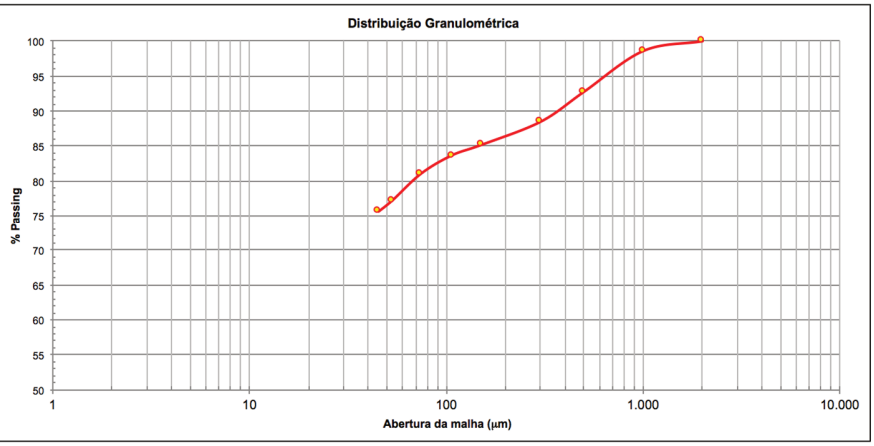
Samples

We collected samples from different iron ore mines in Minas Gerais state for analysis.

Sample 1
Tailings from desliming and magnetic concentration steps, combined
Solids percentage on pulp: 55%;
Solids specific density: 3,60 g/cm^3;
Pulp density: 1,66 g/cm^3.

Table 1 – Particle size distribution of sample 1.

Distribuição Granulométrica	
Mesh (µm)	Passing (%)
2.000	100,0
1.000	98,6
500	92,8
300	88,5
150	85,2
106	83,7
74	81,1
53	77,3
45	75,7
38	
35	
26	
18	
12	
9	
P80(µm)	67,0

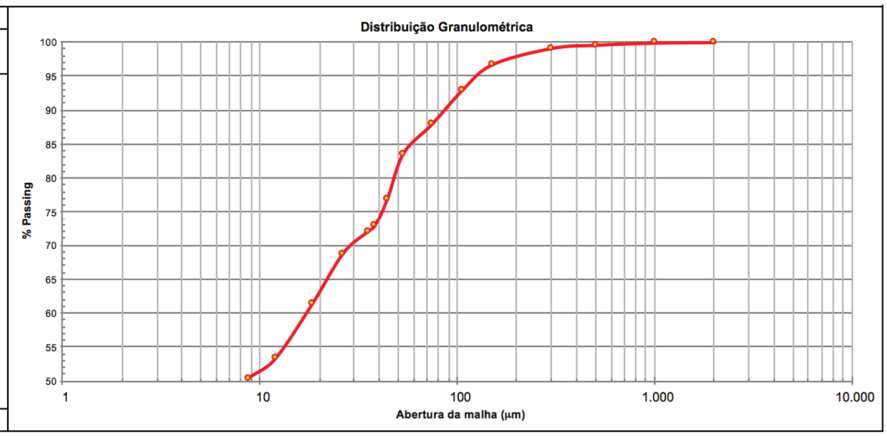


Sample 2

Slimes.
Solids percentage on pulp: 50,6%;
Solids specific density: 3,35 g/cm^3.

Table 2 – Particle size distribution of sample 2.

Distribuição Granulométrica	
Mesh (µm)	Passing (%)
2.000	100,0
1.000	99,9
500	99,6
300	99,1
150	96,7
106	93,0
74	88,0
53	83,7
44	77,0
38	72,9
35	72,0
26	68,8
18	61,3
12	53,3
9	50,4
P80(µm)	48,0

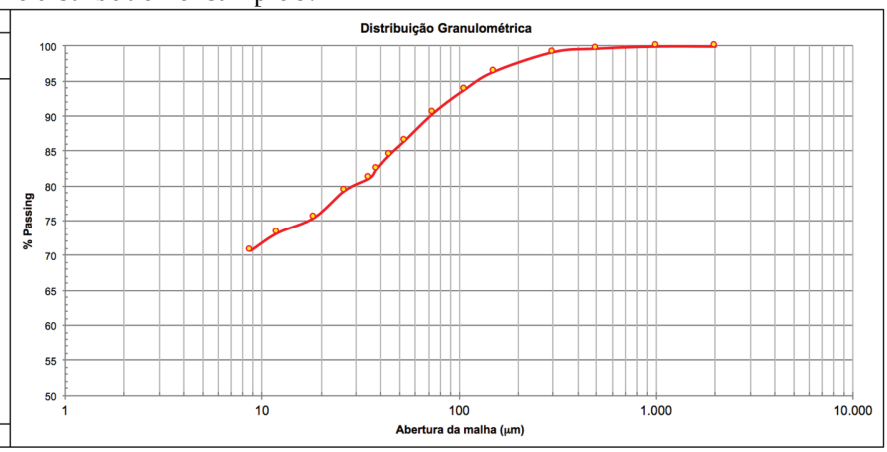


Sample 3

Slimes.
Solids percentage on pulp: 48%;
Solids specific density: 3,32 g/cm³.

Table 3 – Particle size distribution of sample 3.

Distribuição Granulométrica	
Mesh (µm)	Passing (%)
2.000	100,0
1.000	100,0
500	99,7
300	99,2
150	96,4
106	93,8
74	90,5
53	86,6
44	84,5
38	82,5
35	81,2
26	79,4
18	75,5
12	73,3
9	70,8
P80(µm)	28,0



RESULTS AND DISCUSSION

Results of filtration times, moisture on cakes and solids percentage present on filtrate are shown in Table 4.

Table 4 – Tests results

Sample	Average cycle time (min)	Cake moisture (%)
1	12	13,8
2	15	16,4
3	15	20,5

It can be observed by analyzing the results of Table 4 that the higher the percentage of fines present in the sample, the greater the difficulty to perform the filtration and hence higher residual moisture. It is estimated, for all samples analyzed, 3 filtration cycles per hour on an industrial scale operation.

None of cakes, tailings, or slimes, presented released water inside. Although not measured, it was found in caked a high compression and mechanical strength.

The residual moisture results for slimes filtration are similar to those obtained by Guimarães (2011)[2], although the unit filtration rate was not evaluated in this study.

CONCLUSION

Filtration of iron ore tailings and slimes using Matec high pressure filters proved to be technically feasible. Based on the tests carried, Matec supplied to a large Brazilian iron ore producer a complete thickening and filtration plant for combined iron ore tailings and slimes. This plant was installed in two phases and has a total capacity to process up to 1200tph of solids, with filtration cycles averaging 22 minutes. It is composed by nine Matec Magnum 2000x2000/190 plates recessed chamber filter presses, with a typical residual moisture of 15% on the cakes.

Figure 4 – Filtration plant installed in Brazil, phase 1.

Figure 5 – Filtration plant installed in Brazil, phase 2.

Figure 6 – Filtrate water and cakes.

Filtered tailings can bring safety to environmental and society. Besides, lifetime of a deposit is much longer than a dam lifetime. It means that lifetime of a mine itself increases as well. Also, as mentioned before; millions of liters of water will be saved and will be available to be reused at plant process.

REFERENCES

[1]Chaves, A. P. (2013). *Teoria e Prática do Tratamento de Minérios: Desaguamento, espessamento e filtragem* (4th ed.) São Paulo-SP: Oficina de Textos.

[2]Guimarães, N. C. (2011). *Filtragem de rejeitos de minério de ferro visando a sua disposição em pilhas*. (Master's thesis). Programa de Pós-Graduação em Engenharia Metalúrgica e de Minas da Universidade Federal de Minas Gerais, Belo Horizonte.

[3]Andrew Robertson (2011)

[4]Matec, 2012