Sandy Tailing Transport between Thickener and Filtration

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ABSTRACT

There is an increasing trend in iron ore mining in Brazil regarding the disposal and treatment of sandy tailings from concentration processes by reverse cationic flotation techniques. Filtering and later disposal of sandy tailings in piles known as PDR (Tailings Disposal Pile) has been shown to be a rising method to the detriment of known tailings dams.

In the case study in question, the tailings thickening operation is too far from the filtration and stacking point, so it was necessary to consider a material transport mode between the two operations (Thickening and Filtration), which was the tailings pipeline.

The pipeline is 6.7 km long tail and 52.0 m static lift designed to operate with process variations especially in terms of percent solids and variations in the beneficiation plant rate. The drive consists of five centrifugal pumps with 600 HP motors and the piping follows the ANSI B36.10 dimensional standard and the API 5L Grade B material standard with 16 inch diameter.

To support the pipeline sizing a fundamental step was to perform the characterization of the material to be transported. Several tests were performed of granulometry, rheology, abrasiveness, solids density, slurry corrosivity, inclination angle of the pipeline, among others. The results of the tests were used to calibrate the mathematical models.

The pipeline was evaluated considering the steady-state and transient flow regime. The results of the steady-state analysis made it possible to specify the quantity and model of the pumps, as well as to evaluate the velocities and pressure losses. The transient analysis, however, was performed to identify the operating scenarios that lead to the highest pressures and thus confirm the characteristics of the pipelines and consider the necessary hydraulic protections.

INTRODUCTION

Project Features

The tailings pipeline is a system that aims to transport mineral particles together with water or other transport fluid through pipelines. In the work in question, the purpose of the tailings pipeline is to link the thickening operation with the tailings filtration since these operations are approximately 6.7 km away.

The initial pipeline station near the tailings thickener is composed of an agitator tank with a working volume of 3270 m³ and a residence time of 4 hours. The pumping system consists of two centrifugal pump trains, each of which consists of five pumps with 600.0 HP and transmission by speed reducer and frequency inverter.

The pipeline is made up of 16.0 inch diameter 7.92 mm thick tubing and is internally coated with 12.0 mm thick natural rubber. The classes vary due to pressure, being 400 # for the highest pressure sections, 300 # for the intermediate pressure sections and 150 # for the low pressure points. In addition, high pressure ball and knife valves were used to close the pipeline when necessary.

The terminal station, near the tailings filtering, is composed of an agitator tank with a working volume of 4,700 m³ and a residence time of 4 hours. After this tank the flow continues to feed the eight disc filters for later stacking.

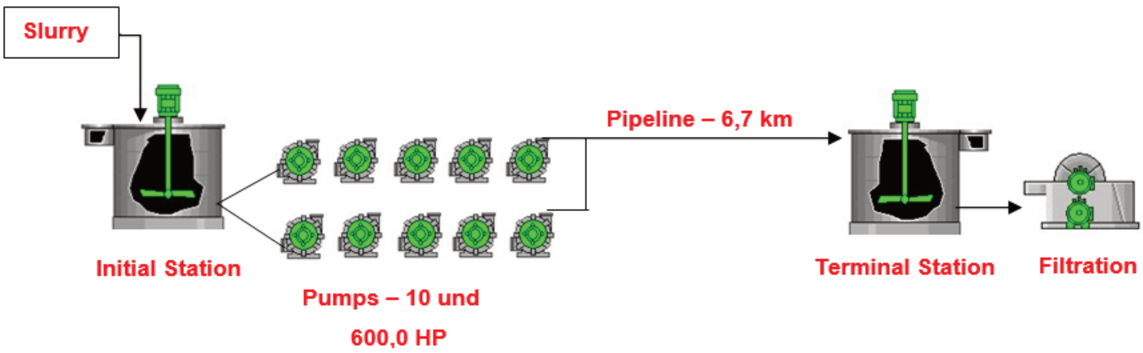

Figure 1 Project Overview

The tailings pipeline is designed for an operating range that takes into account the contents of the existing deposit, the expected percent solids variations for tailings thickener underflow, and the number of processing lines at the beneficiation plant. Table 1 below presents the tailings generation conditions the percent solids values and the maximum and minimum flows:

Table 1 Flotation Tailings Generation Data

Generation Condition	Sandy Tailings (t/h)	Solids Weight (%)	Flow rate (m³/h)
Minimum	976	60	863
Nominal	1 148	65	1 015
Maximum	1 378	70	1 218

The selection of the pipeline route took into consideration some fundamental assumptions, firstly, the pipeline slope cannot exceed the value determined in test to avoid sedimentation of the material within the pipeline. Another point considered was the natural obstacles like highway and rivers. Finally, environmental licensing and construction issues were considered. Figure 2 below presents the geometric profile considered for the tailings pipeline.

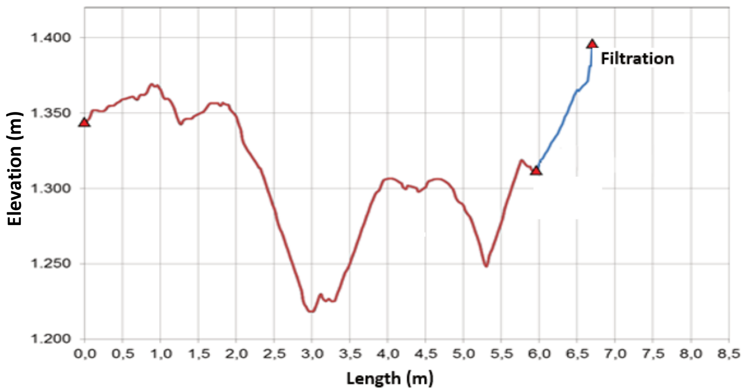

Figure 2 Geometrical Profile of the pipeline

Material characterization tests

Particle size distribution

The particle size distribution tests were performed by SENAI-MG Center for Innovation and Technology, initially using the wet sieving technique and for the fractions of solids below 0.045 mm, the laser particle size analysis technique was used. Laser particle size Cilas 920 liquid. The sample was filtered and oven dried at a temperature not exceeding 100 ° C for a period of 12.0 hours.

Real Density of Solids

The tests were performed by SENAI-MG Center for Innovation and Technology. Density measurements were performed in fractions above and below 0.045 mm. For this purpose a real density analyzer was used using the Helium Stereopicnometer from the manufacturer QuantaChrome.

Rheology

The rheology tests were performed by Brass do Brazil LTDA, through the Anton Paar Rheolab QC rheometer, with concentric cylinder system. In this test the shear rate is varied by recording the value of the corresponding shear stress.

Penetration test

The purpose of this test is to qualitatively determine the degree of compaction of mineral particles. For this test, we used a calibrated mass system, with a tip-type penetrometer and standard weights, and measured the mass needed for the tip to cross the sedimented solid layer in a 600 ml beaker.

Slip and rest angle test

For this test, the slurry is shaken for some time in an acrylic tube to homogenize it. Then the acrylic tube is positioned as specified so that the slurry is kept at rest. After the sedimentation time of 24 hours, it is observed if there is plug formation inside the tube.

Corrosion Tests

The corrosion test was performed at the laboratory Ceelbio Technologic in Ceramic Ltda. The methodology adopted for performing electrochemical measurements is comprised in ASTM G5, G102, G59 G61 standards. The tests were performed in open and closed regime.

Abrasiveness Test

The abrasion tests were performed by the company Spectrum Engineers Consulters Reunites LTDA. The experiments were carried out to determine the relative abrasiveness of the slurry in contact with the work material. The laboratory procedure for testing is defined by the international standard for materials and testing, ASTM G75.

Figure 3 shows the results obtained in the bench tests performed for slurry characterization.

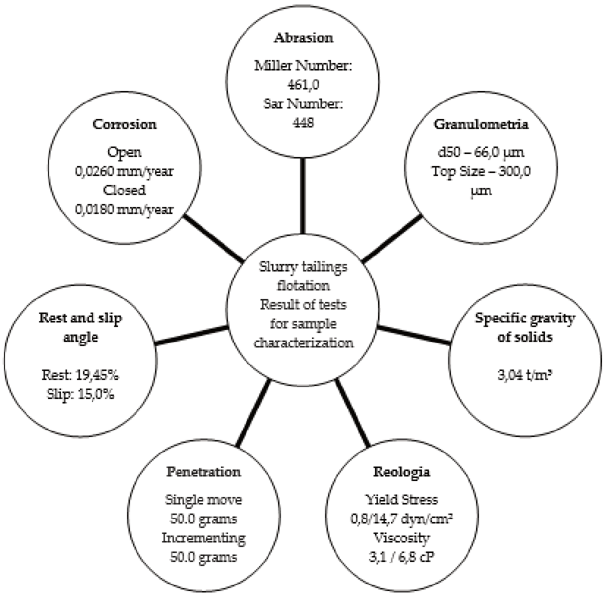

Figure 3 Sample Characterization Result

METHODOLOGY AND ASSUMPTIONS

Sedimentation Speed and Pressure Loss

To determine the pressure drop and the sedimentation velocity of the slurry inside the pipeline, the Modified Wasp model and the Wasp and Slatter model respectively were used. Both models are found in the reference, MIEDEMA (2016).

Duct Specification

For the tailings pipeline project the ASME Code B31.4, "Pipeline transportation systems for liquids and slurries", referring to the 2016 edition, chapter XI, was used. Also considering the addition of internal lining due to the corrosion and abrasion rate in joint actuation.

Hydraulic Criteria

To ensure safe operation of the pipeline, a factor of 5% on the deposition limit velocity and pressure loss was adopted, and the system's piezometric line should not be less than 1.0 Bar in relation to the geometric profile and 3.0 Bar in relation to the maximum allowable pressure.

Centrifugal pumps

For the correct selection of centrifugal pumps of the system, the ANSI HI12.1-I26 standard was adopted. This standard limits the head height per pump stage as well as guiding the maximum peripheral speed of the impeller, both definitions being attributed to the characteristics of the material to be transported.

RESULTS AND DISCUSSION

Results for steady flow

Table 2 shows the increase of the set pressure for the maximum, nominal and minimum flow conditions. In addition, transport velocity and sedimentation velocity conditions are presented in order to show that the tailings pipeline will not operate below the sedimentation limit velocity. Figure 4 shows the hydraulic profile of the system at maximum flow condition. This condition will be used to determine pump characteristics and maximum operating pressure in the pipes.

Table 2 Permanent Hydraulic Conditions

Generation Condition	Static pressure (kPa)	Dynamic pressure (kgf/cm²)	Vel. Transport (m/s)	Vel. Deposition (m/s)
Minimum		23.22	2.27	
Nominal	882.6	28.24	2.67	2.16
Maximum		36.07	3.21	

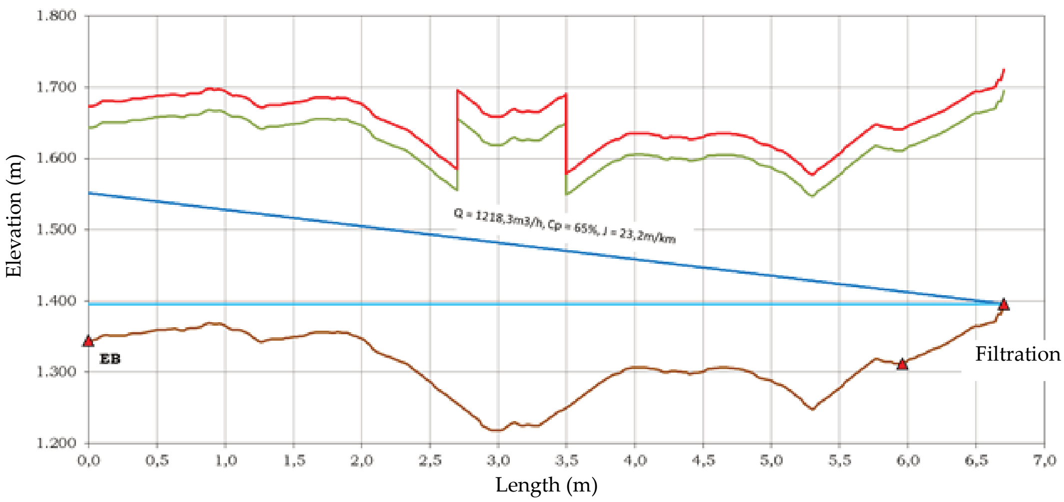

Figure 4 Steady-State Regime Hydraulic Gradient

Results for transient flow

Several simulations were performed in transient regime in order to identify the highest possible pressure condition and through this perform the sizing. The scenario that led to the aforem36entioned condition was the sudden flow stop trip. This scenario led to pressure peaks of 3530 kPa in the initial season and 1724 kPa in the terminal station. Figure 5 below shows a pressure envelope simulation for the flow stop scenario.

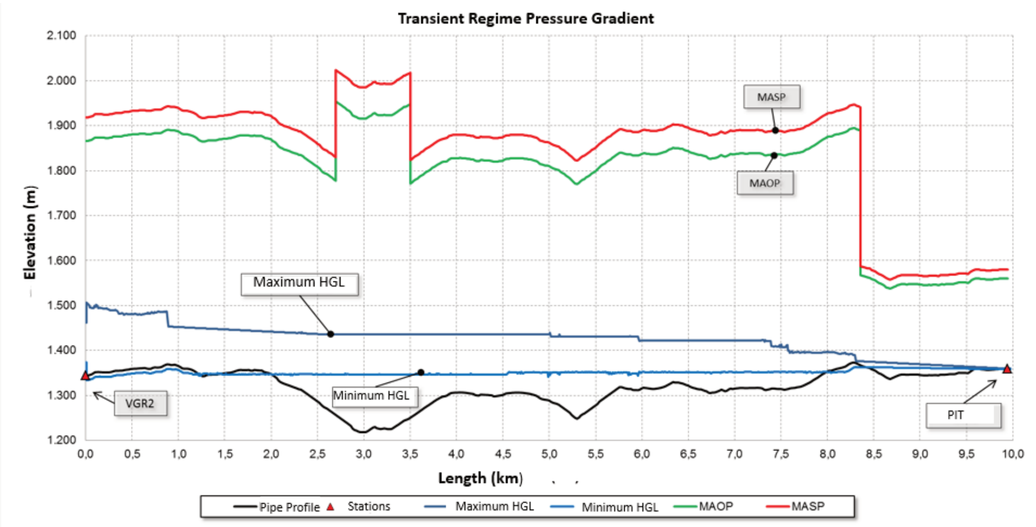

Figure 5 Transient Regime Pressure Envelope

Figure 6 provides the condition for acting pressures, allowable pipe pressures, and pipe fitting pressure classes.

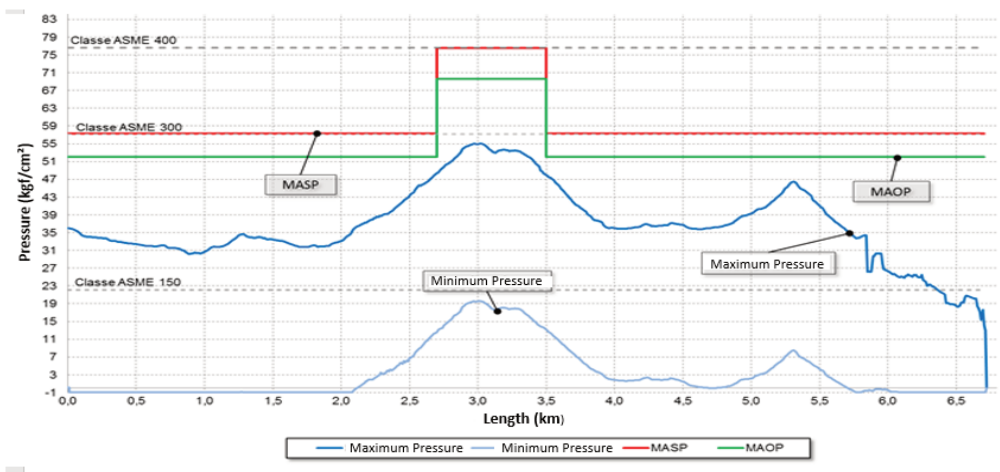

Figure 6 Pipeline pressures and grades

System Overview

After sizing, all system design characteristics were defined including piping, pumps, hydraulic characteristics and others. Figure 7 below gives the overall summary of the tailings pipeline.

Pipeline	Length to Filtration	km	6,7 km
	External diameter / Material	pol	16" / Aço API 5L Gr. B
	Pipe thickness	mm	7,92
	Steel quantity	t	522
	Internal coating / Thickness	mm	Natural rubber / 12,0
Centrifugal pumps	Type	-	Slurry Centrifugal Pumps
	Model	-	Warman 12x10 AHPP
	Amount	Unid.	10 (5 Operating + 5 Reserve)
	AMT Design by pump	mcp	41,08
	Pump Installed Power	kW	440,0
	Frequency inverters	Unid.	10 – On all pumps

Figure 7 System Overview

CONCLUSION

The tailings pipeline was sized as presented in the paper and the implementation is underway with expected operation in 2020.

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