Research Pipeline Transportation Characteristics of Dashi River Tailings

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Abstract

The characteristics of the pipeline transport in the Dashi river tailings mortar are studied in this paper. Based on the transportation of slurry pipeline, the specific proportion and particle composition of the tailings sand static sedimentation of different concentrations of pulp conveyed by the 15 km pipeline transportation of the Dashi River tailings are determined experimentally. Besides, static sedimentation curves of different pulp concentrations are made on the basis of measurement results. According to the transport scale and height difference data, the transport volume and flow velocity of two concentrations of the project are calculated. Finally, the transport plan of the project is determined.

Keywords

Slurry pipeline, Tailings sand, pulp, Static settlement, Critical flow rate of slurry.

1. Introduction

With the continuous development of pipeline transportation technology and the increasingly fierce competition in transportation industry, pipeline transportation technology has been more and more widely used all over the world. In the fields of coal mine and metal mine, the application of pipeline transportation technology has brought many conveniences, and its advantages are far greater than other modes of transportation at present [1]. However, the theory of solid-liquid two-phase slurry transportation in pipeline needs to be further improved. The slurry transportation in pipeline is a way of conveying material particles through pipeline with liquid as carrier and conveying two-phase flow. Compared with other transportation modes, it has the advantages of less energy consumption, less terrain restriction and continuous transportation. It has attracted worldwide attention and has good application prospects [2]. In this paper, the characteristics of pipeline transportation of tailings mortar in Dashier River are studied. The characteristics of tailings in 15 km pipeline transportation of tailings in Dashier River are measured by experiments. Finally, the transportation scheme of tailings in Dashier River is determined.

2. The physical properties of tailings sand materials

There are many factors affecting the properties of the slurry, such as density, particle size and particle size composition, surface physicochemical properties of the particles. Among others parts for the same type of minerals, the most important are particle size and grain size composition.

2.1 The grain size of tailings sand

The sieve analysis method is used to determine the particle size composition of the tailings sand. This method makes the tailings sand sample pass through a standard sieve with different sieve holes, and separate it into several grain sizes, and weigh them separately. The particle size distribution expressed by the mass fraction, which is obtained to calculate and compare the relevant parameters of the pipeline transportation. The experiment was also carried out in 12 groups of each 500g. The experiment has been tested 12 groups, the average particle size composition of the slurry samples is shown in Table1. The composition curve of Tailings sand sample particle size is shown in Figure 1.

The size of the solid particle diameter of the tailings sand is expressed by the particle size, which is generally expressed by d. For the ore with d is equal or longer than 0.07mm, the sieve analysis method will be adopted. For those which is shorter than 0.07mm, the water analysis method will be used, whether it is sieve analysis or water analysis, the particle size of the given ore is limited or graded. The weighted average particle

Table 1:The experimental table of tailing ore sample grain size

Sieve hole diameter (mm)	1.015	0.84	0.5	0.297	0.15	0.104
LessD percentage (%)	100	96.08	84.05	70.23	52.71	42.29
Sieve hole diameter (mm)	0.074	0.061	0.044	0.026	0.019	0.01
Less D percentage (%)	32.13	26.16	20.13	15.37	10.92	7.11

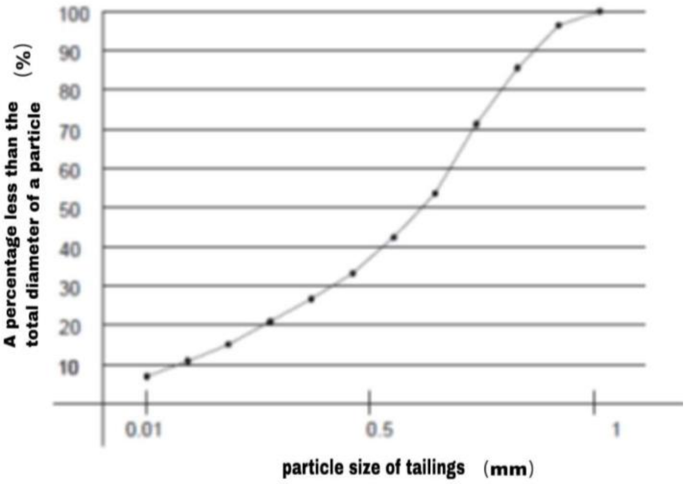

Figure 1: The composition curve of Tailings sand sample particle size

size d indicates the thickness of the entire material.

$$\bar{d} = \frac{\sum(d_i \cdot \Delta p_i)}{\sum \Delta p_i} \quad (1)$$

In formula:

$\bar{d}$---Weighted average granularity, mm;

d_1---Average particle size of a grain size, mm;

Δp_i---Content of a grain size.

And in accordance with the formula, the weighted average particle size of the tailings sand is calculated, that is d=0.263. according to the national standard GB14684-2001, the tailings below 1.015(18 mesh) and from 0.297(100 mesh) to 0.074(200 mesh) accounts for 50.32%. The tailings below 0.074(200 mesh)is 32.31%. Therefore, tailings are fine tailings。

2.2 The destiny of tailings sand

According to the "Geotechnical Test Procedures", the density of tailings sand was determined experimentally. The collected three sets of dry ore samples with a mass of 500g of tailings were measured by the pycnometer method. The results were calculated according to the following formula. The density is shown in the table2.

Table 2: The Density test results diagram of tailings sand samples.

Nm	The density of tailings g/cm3
1	2.431
2	2.436
3	2. 434
Ave	2. 434

3. The tailings mortar experiment on static settlement characteristics

The static sedimentation characteristics of the tailings mortar were determined by static sedimentation experiments. The experiment was carried out in three groups. Each group was observed for the natural sedimentation of the tailings slurry with a weight concentration of 15%, 36% and 48% in a 500 ml glass cylinder. The tailings slurry is prepared by using tailings ore samples and tap water.

Due to the presence of fine particles with extremely slow sedimentation in the tailings mortar, the sedimentation process is relatively slow, and during the sedimentation process of the tailings mortar, the larger particles quickly settle to the bottom of the cylinder, and the fine particles become turbid in the upper layer of the slurry, so the experiment observes the change in the level of the sputum, the experimental results are shown in Figure 2-4.It can be seen from Figure 2-4 that the static sedimentation of the iron tailings mortar with a concentration of 15% has a linear relationship between 0 and 180 min. The sedimentation rate of the slurry is obviously slow between 180 and 450 min, and after 450 min almost is not change; the static sedimentation of the iron tailings slurry with a concentration of 36% is almost linear between 0 and 500 min. The sedimentation rate of the slurry is obviously slow between 500 and 1500 min, and it almost never changes after 1500 min；The static sedimentation curve of the iron tailings slurry with a concentration of 48% is relatively close. It can be seen that the beginning of the curve shows a certain linear change. With the increase of time, the sedimentation of the slurry gradually slows to no longer change from 10h.

4. Calculate the two different critical flow rate of concentrations of slurry

The critical flow rate has a certain relationship with the concentration, material and pipe diameter of the slurry. In the pipeline design, the transport concentration of the slurry has a great influence on the system parameters. Considering whether the slurry is concentrated and transported is beneficial to the operation of the equipment. So the author makes a comparison between the concentration of 15% and 48% in the experiment.

In formula：

$$v_c = 9.6[gD(\frac{s-s_m}{s_m})]^{0.25} \times C_v^{0.25} \times (\frac{d_{85}}{D})^{0.25} \quad (2)$$

In formula:

V_c---Slurry slurry flow rate, m/s；

D---Pipe diameter, mm;

S---Pulp proportion, S=3；

S_m---Certain concentration of slurry；

C_v---Slurry volume concentration,

$$C_v = C_w / C_w + S(1-C_w) \ ;$$

d_{85}---Less than a certain particle size, 85% of the particle size。

Critical flow rate at 48% pulp:

$$V_c = 0.255(1 + 2.48\sqrt[3]{P}\sqrt[4]{D})\beta \quad (3)$$

In formula:

Vc--- Pulp critical flow rate, m/s;

D---Pipe inner diameter, mm;

S---Pulp proportion;

C_w---Slurryweight concentration;

P, β---p=100C_w/1- C_w, β=S-1/1.7.

There is a following requirement for the maximum deliver volume:

$$Q_{max} = 2826 D_{max}^2 \times v \quad (4)$$

$$D_{max} = D\text{-}2\delta_{min} \quad (5)$$

In formula:

D_{max}---Maximum diameter in the pipe, m;

V---Pipeline flow rate, m/s;

Table 3: Concentration is 15% slurry pipe diameter critical flow rate

Pipe outer diameter D(mm)	Critical flow rate V3（m/s）
93	1.3
65	1.1
100	1.6
150	2
206	2.81
307	3

D---Pipe inner diameter, m;

δmin---Minimum structural wall thickness of the pipe, m;

Get the following data from table in Table 3 and Table 4.

In contrast, when the conveying concentration is 15%, the required pipe diameter and flow rate are large, which will increase the demand for power equipment and transportation equipment in engineering. When the transport concentration is 48%, the flow rate and the pipe diameter are reasonable in terms of the critical flow rate and the actual flow rate, and will not bring excessive demand to the actual project. Therefore, the slurry with a concentration of 48% is selected and the transportation pipeline is designed at this concentration.

Table 4: Concentration is 48% slurry pipe diameter critical flow rate

Pipe outer diameter D(mm)	Critical flow rate V3（m/s）
67	1.22
100	1.32
125	1.41
149	1.64

150	2.04
206	2.1

5. Calculation results of tailings mortar transport

Calculation results in table 5.

Table 5: Calculation results of tailings mortar transport

Transport concentration（%）	48
Dry tailings volume（ t/h）	150
Height difference（ m）	70
Conveying distance （ m）	15000
Conveying flux（ m3/h）	184
Pulp capacity（ t/m3）	1.6
Selected pipe diameter（ mm）	206
Pulp velocity（ m/s）	1.6

6. Conclusion

1) The physical characteristics of the material in the tailings of Dashi River are determined through experiments, including density, particle size and grain size composition.

2) The static settling curve of the slurry with different concentration is obtained through the static settling characteristic test of tailings slurry. According to the experimental results, the slurry transport concentration of the Dashi River tailings is obtained .

3) According to the given transport scale and height difference data, the transport volume and flow velocity of two concentrations of the project are calculated. Finally, the transport plan of the project is determined.

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