An Integrated Technology of Dewatering and Consolidating Tailings

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ABSTRACT

The process model of consolidating and discharging tailings is proposed: Tailings from mill plant-Adding cementing material-Stirring-Dewatering-Transporting and discharging. The key issue is to add the cementing material to the tailings mortar before dewatering and consolidation. Industrial test is carried out, and the results show that, 1) the proposed process model is feasible; 2) the settling rate of tailings from Xishimen Iron Mine is relatively fast, and the settling rate is affected by cement content and hydration period; 3) the capacity of ceramic filter is high at the beginning, but it declines with the process of dewatering; in comparison, disc filter shows better filtering and processing capabilities; 4) the handling capacity of the filter becomes higher with the increase in the concentration of cemented tailings slurry; 5) the compressive strength of the consolidated tailings specimen with cement content of 2% reaches 0.727MPa and the consolidated tailings specimen cannot be muddy when encountering water.

KEYWORDS: Tailings; Cementing material; Dewatering; Discharge; Tailings pond;

INTRODUCTION

The consolidation and discharge of tailings refers to the technology of adding a certain percentage of cementing material into tailings and then condensing and dewatering the slurry in order to make them become consolidated bodies. After that, these bodies will be placed on the earth surface in place, without the necessity of building tailing ponds. This technology will thoroughly change the traditional way of discharging tailings[1-7].

SELECTING THE PROCESS MODEL OF CONSOLIDATING AND DISCHARGING TAILINGS

There are two ways of adding cementing material into tailings. One is to add cementing material into tailings slurry before concentrating and dewatering the slurry, after being stirred uniformly, the slurry will be dehydrated with filtration equipment. The other is concentrating and dehydrating the tailings slurry first and then adding cementing material by intense agitation. Correspondingly, there are two process models for consolidating and discharging tailings.

Model 1: Tailings feeding → Adding cementing material → Stirring → Filtering and dewatering → Transporting and discharging

Model 2: Tailings feeding → Filtering and dewatering → Adding cementing material by intense stirring → Transporting and discharging

The difference between Model 1 and Model 2 is that Model 1 is to add cementing material into tailings slurry before dehydrating and consolidating the slurry. Theoretical analysis and test show that, because of the low proportion of cementing material (less than 3%), after adding the cementing material into the dewatered slurry, it is very difficult to stir the dewatered slurry uniformly even by intense stirring, so the cementing material cannot hydrate fluently, which will result in the disadvantages of bad effect of consolidation, large consumption of cementing material, and high cost of stirring. Therefore, Model 1 is better and it will be adopted as the process model for consolidating and discharging the tailings from Xishimen Iron Mine. In order to carry out this process model successfully, relevant experimental analysis and small-scale industrial test will be conducted.

SETTLEMENT CHARACTERISTICS OF THE TAILINGS SLURRY WITH ADMIXTURE OF CEMENTING MATERIAL

The mud content in the tailings from Xishimen Iron Mine is very high, and the tailings slurry is extremely hard to dewater. Due to these reasons, settlement test on both pure tailings slurry and cemented tailings slurry with different concentration will be conducted, in order to obtain the settlement evolution of these slurries on various conditions, as well as analyze the settlement evolution of these slurries with concentration and mix proportion.

(1) Influence of different slurry concentration on settling velocity

Fig. 1 shows the effect of concentration on the settlement of pure tailings slurry, while Fig. 2 displays the effect of concentration on the settlement of cemented tailings slurry with the admixture of cement (cement content: 3%).

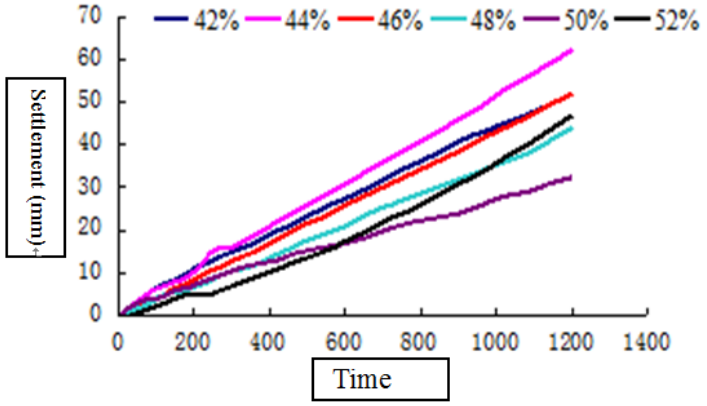


Figure 1: Settlement of the pure tailings slurry versus time with the variation of concentration

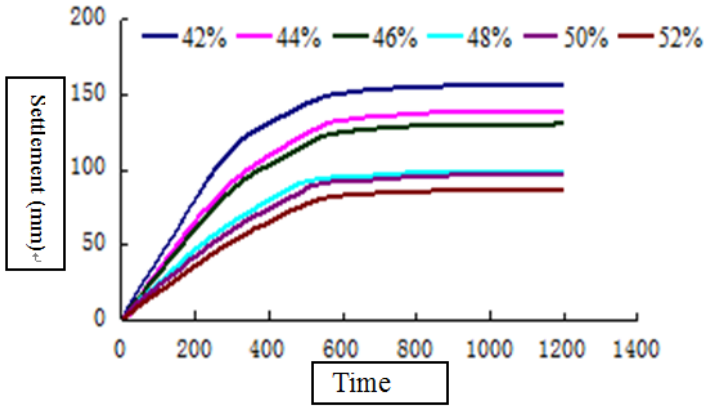


Figure 2: Settlement of the cemented tailings slurry versus time with the variation of concentration

The experimental results illustrate that, settling velocity of the pure tailings slurry slows down with the increase of its concentration. Settling velocity of the cemented tailings slurry is obviously higher than that of the pure tailings slurry. Besides, the settlement of the cemented tailings slurry stops at the time of 10 min. This is because the cement hydration occurs in the cemented tailings slurry.

(2) Influence of hydration degree of the cementing materials on settling velocity

Take Portland cement 32.5# as example, concentration of the cemented slurry is respectively 44% and 48% with the same cement content of 3%. Fig. 3 shows the effect of hydration time on the settlement of the cemented slurry with concentration of 44%, while Fig. 4 demonstrates the effect of hydration time on the settlement of the cemented slurry with concentration of 48%.

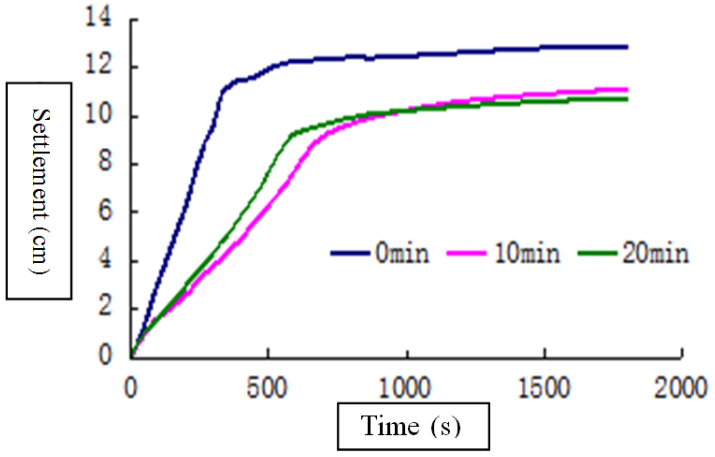


Figure 3: Effect of hydration time on the settlement of the cemented slurry with concentration of 44%

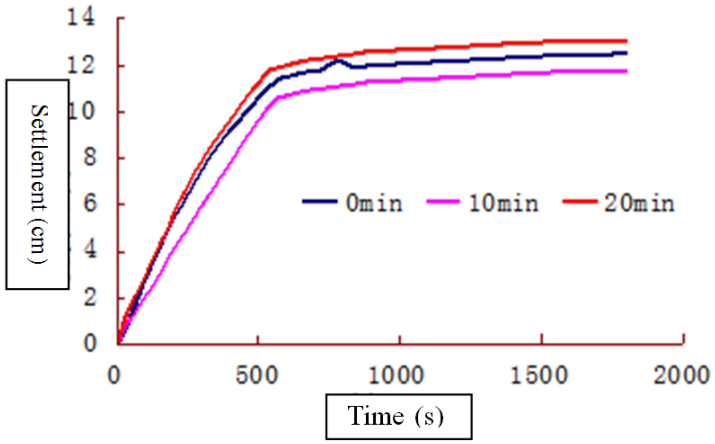


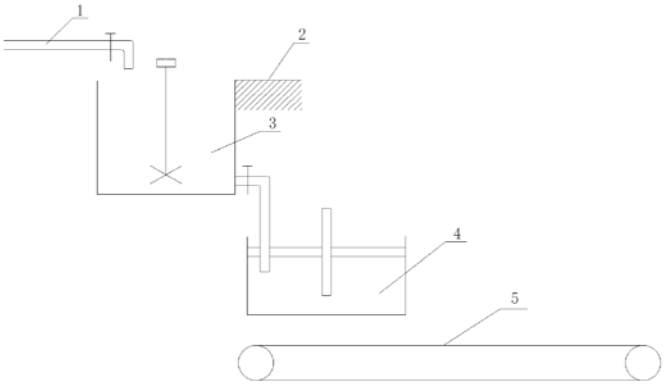
Figure 4: Effect of hydration time on the settlement of the cemented slurry with concentration of 48%

The experimental results illustrate that, within a certain time, the settling velocity of the cemented tailings slurry can slow down by adding cementing materials in advance. When the concentration of the cemented tailings slurry is 48%, 10 minutes in advance is the best time to add cement. This result agrees very well with the process model of cementing and discharging tailings from Xishimen Iron Mine.

INDUSTRIAL TESTS ON DEWATERING AND CONSOLIDATING TAILINGS

Small scale industrial tests are carried out according to the process model of dewatering and consolidating tailings, the technological feasibility of cementing and discharging tailings is tested, the effect of both disc and ceramic filters on concentrating and dewatering tailings slurry is also verified. In addition, the influence of Slag Portland cement on the consolidation effect of tailings is tested. In combination of the testing results, the process model and relevant parameters are optimized, which will provide reference for designing the discharging system at the north part of the collapse pit in Xishimen Iron Mine.

The cementing and discharging process of tailings mainly includes supplying tailings, stirring, dewatering, consolidation, emission and sample inspection, as shown in Fig. 5. Industrial test system is constructed near the discharging workshop of the mill plant. Testing facilities include pipelines for supplying tailings, platform for adding cementing materials, agitation vat, filter, belt conveyor system, pickling bath, as shown in Fig. 6.



1-Pipe for supplying tailings slurry, 2-Platform for adding cementing materials, 3-Agitation vat, 4-Filter, 5-Belt

Figure 5: Industrial test process for consolidating and discharging tailings

Figure 6: Industrial test facilities

Industrial trials are carried out in three stages:

1) The test of consolidation dewatering is carried out by using of ceramic filter machine.

2) In the second stage, ceramic filter testing machine produced by another producer filter is used.

3) Disc filter is used in the third stage

RESULTS AND DISCUSSIONS

(1) Results and discussions on the data from the first stage

By analyzing the data from the first stage, it is found that the processing capability of the ceramic filter increases with the increase of the concentration of cemented tailings slurry. The minimum processing capacity of the ceramic filter is 240.55kg/h·m2, and the maximum processing capability is 456.895kg/h·m2. After filtering, the average water content in the cemented tailings slurry is about 20%.

Regression analysis (as shown in Fig. 7) of the data from the first stage shows that, relation between the processing capability of the ceramic filter and the concentration of cemented tailings slurry can be written as the following form:

$$q = 1.875v2 - 131.53v + 2583.9 \quad (1)$$

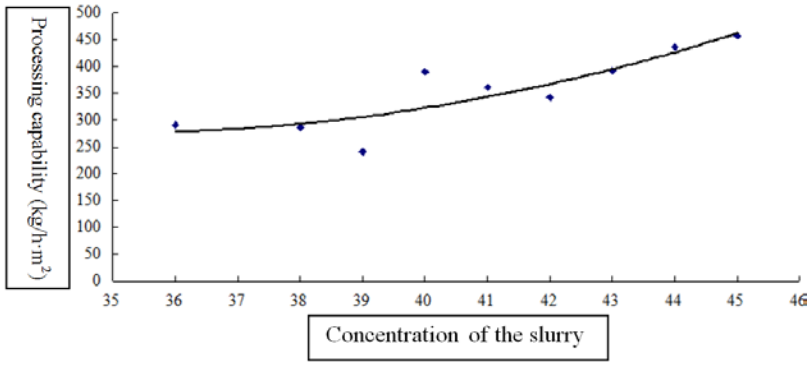


Figure 7: Relationship between processing capability of the ceramic filter and slurry concentration (first stage)

(2) Results and discussions on the data from the second stage

The ceramic filter used in the second stage is different from that used in the first stage. Regression analysis (as shown in Fig. 8) of the data from the second stage shows that, relation between the processing capability of the ceramic filter and the concentration of cemented tailings slurry can be written as the following form:

$$q = 10.286v - 37.286 \quad (2)$$

With the increase of the concentration of cemented tailings slurry, the processing capability of the ceramic filter increases. The processing capacity of the ceramic filter is in the range of 250-400kg/h·m2, and the maximum and minimum processing capabilities are respectively 432kg/h·m2 and 324kg/h·m2. After filtering, the average water content in the cemented tailings slurry is almost 20%.

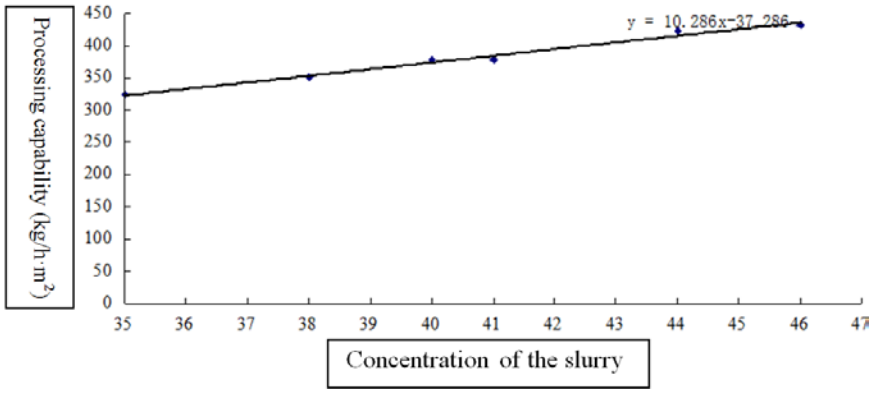


Figure 8: Relationship between processing capability of the ceramic filter and slurry concentration (second stage)

(3) Results and discussions on the data from the third stage

Disc filter is used in the third stage. Table 1 lists the testing results.

In comparison, the processing capability of the disc filter is obviously higher than that of the ceramic filter, without the need of picking. Besides, some other properties of the disc filter can also meet the requirement of the dewatering and consolidating system. So it is considered to use the disc filter to dewater and filter the tailings slurry.

Table 1: Processing capacity of the disc filter

Concentration range /%	Mortar concentration /%	Cement content /%	Specific yield /kg·m^{-2}·h^{-1}	Average yield /kg·m^{-2}·h^{-1}
<30	3	3.0	260.16	312
	23	3.0	268.80	
	28	3.0	318.72	
30~34	32	2.5	08.96	403
	32	2.0	384.00	
	33	2.0	380.16	
	33	3.0	441.60	
35~37	35	2.0	313.00	418
	36	2.5	412.80	
	37	3.0	466.56	
	37	3.0	480.00	
38~40	38	2.0	480.00	455
	39	2.0	424.32	
	39	2.5	462.72	
41~45	41	3.0	576.00	499
	41	2.5	547.20	
	44	1.5	433.92	
	45	2.0	490.56	
	45	1.8	469.44	
	45	1.5	480.00	
>45	46	2.0	475.20	468
	47	3.0	462.72	

(4) Effect of cement content on processing capacity

Under the condition of the same concentration of tailings slurry, the effect of different cement content on the processing ability of the disc filter is shown in Table 2. According to the data from Table 2, on the condition of the same slurry concentration, with the increase of cement content, processing capacity of the filter increases. This is because, with the increase of cement content, the products of cement hydration increase, which is helpful to forming flock aggregate and favorable for the filter to dewater and filter.

Although increasing the cement content in the cemented tailings slurry can increase the processing capacity of the disk filter, but the cost will increase. In addition, increasing the cement content will increase the hydration products, which can affect the service life of the cloth of the disc filter. Hence, in the actual production process, cement content should be selected properly with the need of the project.

Table 2: Effect of cement content on the processing capacity of the disc filter (kg/h·m^2)

Cement content/%	Concentration of the cemented tailings slurry/%				
	32	33	39	41	45
1.5	-	-	-	-	480
1.8	-	-	-	-	469
2.0	384	380	424	-	491
2.5	409	442	463	547	-
3.0	-	-	-	576	-

(5) Analysis of the strength of the consolidated tailings body

The relation between cement content and uniaxial compressive strength of the consolidated tailings body was shown in Fig. 9. The uniaxial compressive strength reaches 0.541MPa when cement content is 1% while it reaches 0.727MPa when the cement content is 2%.

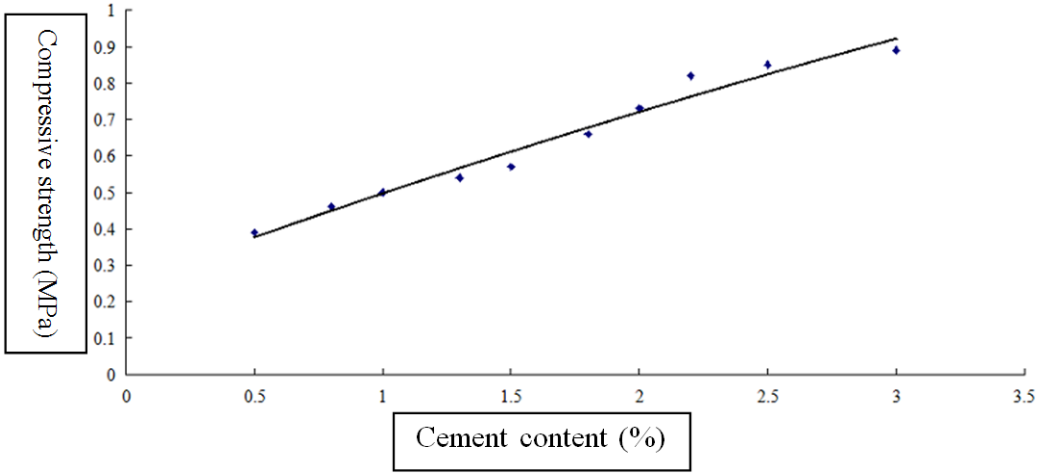


Figure 9: The relation between cement content and uniaxial compressive strength consolidated tailings body

Fig. 10 shows the consolidated tailings pile after dewatering in the industrial test.

Figure 10: Consolidated tailings pile after dewatering

CONCLUSIONS

(1) Testing results illustrate that process model 1 (Feeding tailings → adding cementing material → stirring→ filter dewatering → transporting and discharging) is feasible.

(2) The settling velocity of cemented tailings slurry from Xishimen Iron Mine is relatively fast, and cement content and its hydration time affect the sedimentation rate.

(3) The initial processing capacity of ceramic filter is high, but with the progress of dewatering and filtering, the processing capacity decreases rapidly and the average processing capacity becomes low. In comparison, although the disc filter costs more power and energy, its dewatering effect is better and the processing capacity is higher.

(4) With the increase of the concentration of cemented tailings slurry, the processing capability of ceramic filter (or disc filter) will increase, and the processing capacity of the disc filter is better than that of the ceramic filter.

(5) Under the condition of the same concentration of slurry, with the increase of cement content, processing capacity per unit area of the disc filter increases.

(6) The compressive strength of cemented tailings block specimen reaches 0.727MPa when cement content is 2%. Meanwhile, when cement content is 2%, the cemented tailings block specimen will not be mudded when confronted with water.

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