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ORIGINAL ARTICLE

Effect of Initial Pulp Concentration on Particles Settling Velocity in various regions of Thickeners

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ABSTRACT
The objective of water recovery in thickeners is to increase the solid concentration at the underflow and to obtain clear water at the overflow. All thickener surface area calculation methods have been based on Coe and Clevenger theory which states that settling velocity in each layer in the free settling region is only a function of solid concentration in that layer. In this research, the effect of feed solid on the settling velocity of each layer was studied by batch settling tests. The results of samples of copper, lead and zinc and coal with the density of 2.7 g/cm³, 3.75 g/cm³ and 1.63 g/cm³, respectively, indicated that unlike the Coe and Clevenger assumption, feed solid concentration has an effect on the settling velocity of layers even in the free settling region. For the coal sample, in a layer with the solid concentration of 16% with changing the initial concentration from 2% to 10% and with adding 35g/t flocculant the settling velocity varied from 0.25 cm/min to 0.96 cm/min. The study of the effect of initial concentration on thickener unit area showed that for the coal sample with the 15 g/t, 25 g/t, and 35 g/t flocculant the highest unit area was needed for the initial concentration of 10%, 6%, and 8 %, respectively.
Keywords: Thickening, Settling velocity, Free Settling Region, Flocculation

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INTRODUCTION

1.1 Settling capacity

Settling capacity for a sedimentation unit is directly proportional to the area of reservoir sedimentation and is characterized by settling velocity in the free settling zone. This velocity does not depend on the depth of the liquid. Settling pulp passes from various regions with different dilutions between dilution of the feed and the final underflow dilution [1, 2, 3, 4, 5, 6]. The region which has the lowest rate of sedimentation, determines unit area because of all solid materials ultimately must pass through this zone. This area is located in the concentration range of free settling. Therefore, unit area for a thickener, are calculated in this zone [7, 8].

2.1 Relationship between sedimentation rate and initial concentration

Concentration of solids in the feed is one of the most important affected factors for the selection of equipment in solid- liquid separation. Sometimes for increasing the solid separation rate, the feed must be diluted. This can occur in flocculation operation in a thickener. When high concentration of solids in the feed (25 wt %) with flocculant is used, the feed may have different structure that significantly settles slower. Flocc structure (size and shape) plays an important role in settling velocity for particles. Under conditions of high density pulp (thick), Flocs are larger and form a network structure and consequently settling velocity decreases. The feed can be diluted with water to increase settling velocity in these conditions [9].

3.1 The importance of research Interkarbon coal preparation plant is located in Zarand, a city in southeast of Iran. This plant has processed old tailings of the Zarand coal washing plant. In this plant a thickener has been designed based on the 5 percent solids in the feed. Due to changes in the properties of entering feed to the thickener, such as percent solids, thickening operation has been unsuccessful. In other words, entered pulp to the thickener has filled all of space without separating the solid phase from liquid and became eventually overflow. The problem was solved by dilution method for thickener feed and results showed that the thickener had a high efficiency. The modified thickener performance is showed in Figure

1. The results of twice thickener showed the flux that limits solid amount passing of this thickener by Coe & Clevenger method is related to a layer with 12 percent solids in the feed and required area in this method does not depend on solid percent in enter feed. Also by Fitch & Talmage method, 9 percent solids in compare to 4 percent solids in the feed needed to lower unit area and this was unlike in practice. Nowadays the most thickener use dilution of the feed for enhancing the capacity of thickeners, such a method can be pointed Educ. In this study, validity of the main assumptions used in thickener design relationships that sedimentation velocity of each layer depends only on its concentration, were studied.

MATERIALS AND METHODS

1.2 Experimental details

Materials

In this study, a sample of three different materials was used for the settling experiments.

- Coal refuse (average density: 1.6 g/cm^3) related to thickener inter of Interkarbon coal preparation plant with 80% of particles smaller than 35 µm.
- Copper ore (average density: 2.7 g/cm^3) with 80% of particles smaller than 80 µm.
- Lead & zinc ore (average density: 3.7 g/cm^3) with 80% of particles smaller than 55 µm.

Settling test method

Settling tests were carried out in glass cylinders with a diameter of 10 mm and volume of 1000 mL. For each experiment, the cylinder was filled with specific weight of one of the three materials and water was added to the cylinder until the total volume was reached to 1000 mL. If needed, the required amount of flocculant was added to the cylinder and the content was mixed well using a mixer then mud line height versus time was recorded.

By dissolving solid flocculant in water, a flocculant solution with concentration of 0.5% was prepared and added to the pulp in each related experiment. The flocculant used in these experiments was Polyacrylamid (A65) which is normally used by Interkarbon coal preparation plant. It should be noted that flocculant according to ISO 10.86 standard was used just during 24 hours and after this time, new flocculant was constructed again.

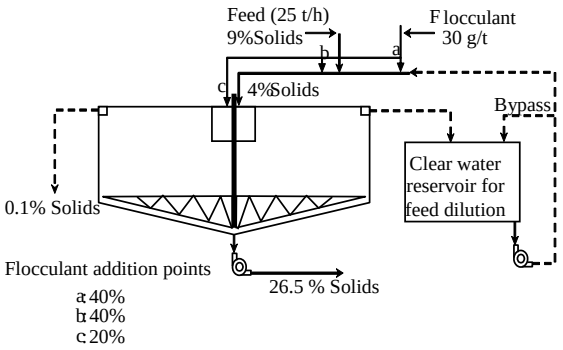

Figure 1: Thickener designed for coal refuse of the Interkarbon coal preparation plant by food dilution to 4 percent solids

Effect of mixing

Mixing was done by inverting the test cylinder after the addition of flocculant solution. An intermediate number of inversions (five) gave the best results [10, 11, 12]. Due to loss of much amounts of pulp by inverting cylinder and error in the test was used from a punching mixer for liquid displacement and mixing operation (Figure 2).

2.2 Experimental design

Settling tests were carried out on the samples of coal refuse, copper and lead & zinc ores in order to investigate the shape factor and floc structure. For the coal sample, by adding different flocculant concentrations, the clarity of the liquid in the overflow was studied.

For the coal sample, the settling tests were started by changing the initial concentration from 2 to 10% with 2% distance and from 15 to 30% with 5% distance. The flocculant concentrations were 15, 25 and $35\,g/t$. To determine the error of settling tests, tests with percent solids of 2, 4 and 8% were repeated between two or three times and the relative deviation for settling velocity as an index of experimental error was calculated. The average deviation for these experiments was 0.13.

The settling tests for copper, lead & zinc samples without flocculant were done by changing the initial concentration from 5 to 40 percent with 5% distance. Due to ease of mud line observation, the test was repeated once only.

Figure 2: The used mixer for sedimentation tests

RESULTS AND DISCUSSION

1.3 Effect of initial pulp concentration on particles settling velocity in various regions of thickeners

All thickener surface area calculation methods have been based on Coe and Clevenger theory which states the settling velocity in each layer in the free settling region is only a function of solids concentration in that layer [13]. But the results of samples of copper, lead and zinc and coal with the density of 2.7, 3.75, and 1.63 g/cm^3, respectively, indicated that unlike the Coe and Clevenger assumption feed solids concentration has an effect on the settling velocity of layers even in the free settling region. However, the relationship of velocity and initial concentration is a function of two or three degrees in above layers of the cylinder that they are diluted. But this relation in the bottom layers is a function with six degrees.

The coal sample

Figure 3 shows a layer with a solids concentration of 16% with changing the initial concentration from 2 to 10 % and adding three flocculant dosages.

Settling velocity for each concentration was calculated by drawing the tangent on the settling curve at any point (Fitch and Talmage method). In according to Coe and Clevenger assumption, the settling velocity versus feed percent solids diagram must be fitted into a straight line (parallel to the x-axis). In other words, the settling velocity does not depend on the initial percent solids in the pulp. But the results did not confirm this for the coal sample. Tests on samples of copper and lead & zinc without adding the flocculant were performed to investigate the effect of solid density.

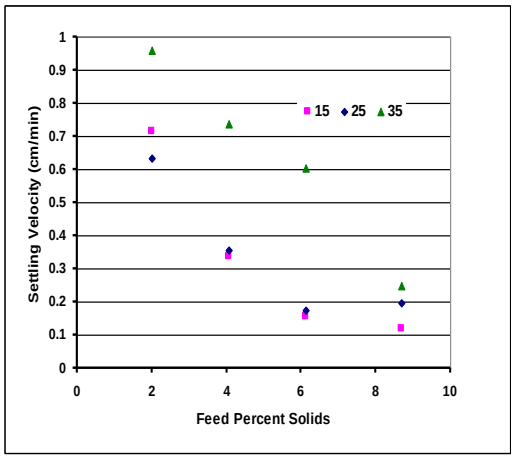

Figure 3: The trend of velocity variations versus changing the initial concentration in a layer with a solids concentration of 16% for coal sample by adding three flocculant dosages.

The copper sample

For the copper sample, trend of velocity variations in Figure 4 is shown with varying initial concentration from 5 to 35% in a layer with 35% solids without flocculant. Unlike the Coe and Clevenger assumption,

the sedimentation rate in a layer with 35% solids concentration is dependent on the initial concentration in the settling test.

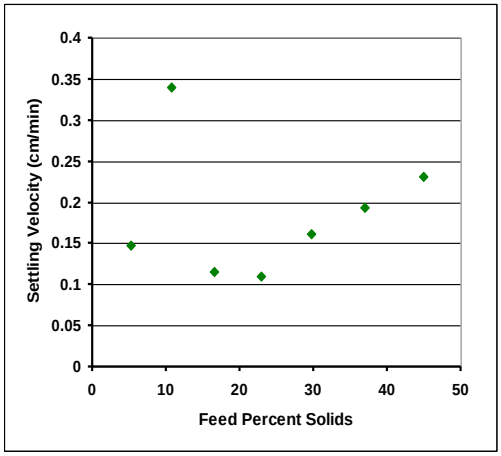

Figure 4: The trend of velocity variations versus changing the initial concentration in a layer with a solids concentration of 35% for copper sample without flocculant

The lead & zinc sample

Settling tests for lead & zinc samples like the samples of copper were performed to investigate the effect of solid density on the settling velocity in different feed percent solids in the same layer with 35% solids. Figure 5 exhibits trend of velocity variations with changing the initial concentration from 5 to 35% in a layer with 35% solids without flocculant for this sample. By comparing Figures 4 and 5, it can be seen that the specific gravity of solids also is affected on settling velocity of particles in a layer with specific concentration. Otherwise it must identify for copper and lead & zinc samples in the layer with 35% solids, but it is not.

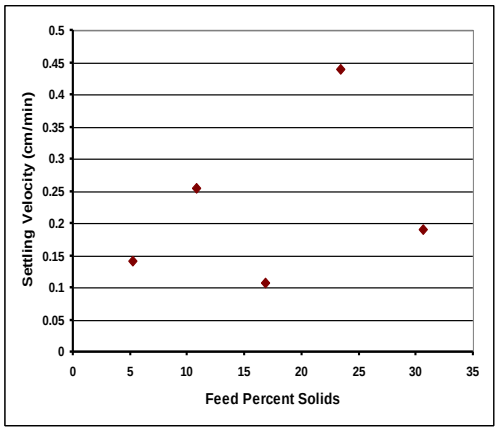

Figure 5: The trend of velocity variations versus changing the initial concentration in a layer with a solids concentration of 35% for lead & zinc sample without flocculant.

Effect of initial concentration on the unit area of the thickener

The research on the Effect of initial concentration on the unit area of thickener for coal sample indicated that the required surface of each thickener is dependent on flocculant dosage. As mentioned earlier, settling tests on samples of coal with different initial concentrations of 2 to 10 percent were done. With the 15, 25, and 35 g/t flocculant the highest unit area needed was for the initial concentration of 10, 6, and 8 %, respectively. Figure 6 displays the required unit area for different feed percent solids by changing the flocculant dosage.

Also, the highest unit area needed was for the initial concentration of 5% and 15% in feed, respectively, for copper and lead & zinc samples.

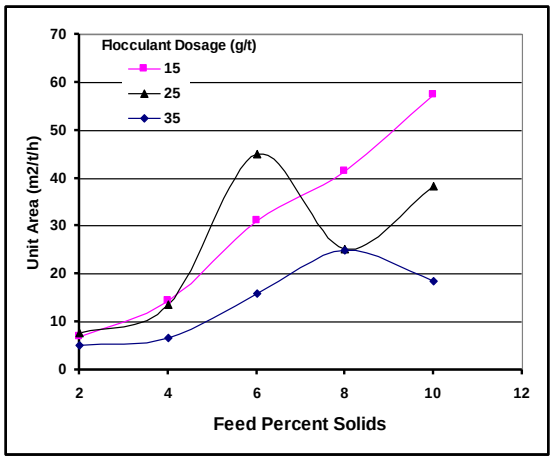

Figure 6: Relationship between initial concentration of pulp and unit area of thickener, for coal sample by changing the amount of Flocculant.

CONCLUSION

Effect of initial concentration on the sedimentation velocity of a layer with a specific concentration demonstrated that unlike the Coe and Clevenger assumption, the settling velocity of the each layer is depend on both initial concentration and density of the solids.

For the coal sample, in a layer with a solid concentration of 16% with changing the initial concentration from 2% to 10 % and adding 35 g/t flocculant the settling velocity varied from 0.25 cm/min to 0.96 cm/min. For the copper sample, in a layer with a solid concentration of 35% with changing the initial concentration from 5% to 35%, the settling velocity varied from 0.11 cm/min to 0.34 cm/min.

For the lead & zinc sample, in a layer with a solid concentration of 35% with changing the initial concentration from 5% to 35%, the settling velocity changed from 0.11 cm/min to 0.44 cm/min.

For the coal sample with the 15, 25, and 35 g/t flocculant the highest unit area was needed for the initial concentration of 10, 6, and 8%, respectively.

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