Lab #7 – Clarification and Thickening

Name: ______________________________ Grade: ___________ Feedback:

Group Name: _________________________ Day: ☐M ☐T

Pledge: "On my honor as a Virginia Tech student, I have neither given nor received unauthorized assistance on this assignment." Initial_____

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https://ready.vt.edu/well.html

If you answer yes to any questions in the Hokie Health survey (questions can be posted in the syllabus), you must not attend class in person. Notify me by email and contact Schiffert Health Center for testing and quarantine protocol.

Introduction

The unit operations used in the mineral processing industry typically require water as the medium in their grinding, sizing and separation processes. As a result, a "thickener" is normally required downstream to remove water from the solids (dewater) and to remove solids from the water (clarify). Thickeners operate by providing sufficient residence time within the tank to allow solids to settle under the influence of gravity. The settling increases the solids concentration of the underflow while simultaneously promoting the formation of a clear liquid overflow.

Most thickeners consist of a large volume cylindrical tank with a low height-to-diameter ratio. The tank is equipped with a center feed well into which dilute feed slurry is introduced. The slurry flows radially out towards an overflow weir that is located around the periphery of the tank. Most of the solids settle out of the uppermost layer of water as the slurry passes from the center well to the overflow weir. The clarified water is normally collected as overflow and passed back to the plant for reuse as process water. Settled solids are intermittently dragged towards a centrally located underflow port using a series of rakes. The rakes are rotated around the tank by a central drive mechanism. Depending on the plant layout, the underflow is either passed to a second stage of dewatering/drying or is pumped away to a disposal area.

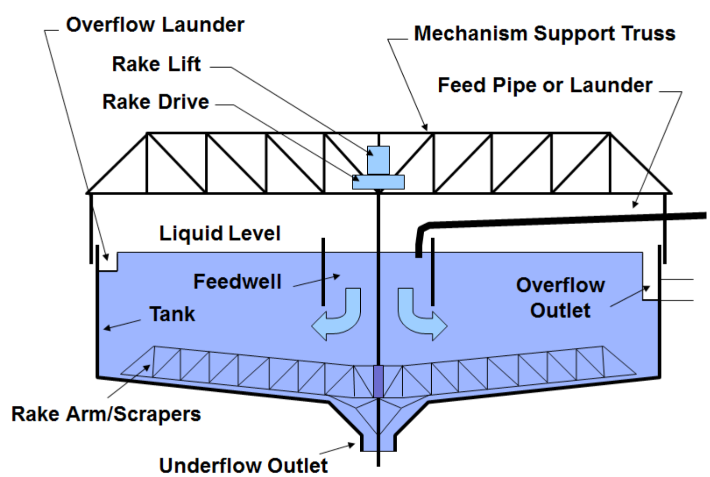


Figure 1. Industrial thickener/clarifier.

In cases involving very fine solids, thickeners require the addition of chemicals to promote particle size enlargement that is necessary to achieve high settling rates, good overflow clarity and good underflow solids concentrations. The most common types of chemicals include:

- Coagulant — A reagent that is used to modify (usually neutralize) the surface charge of suspended particles in a manner that promotes aggregation.
- Flocculant — A natural or synthetic water-soluble organic polymer of high molecular weight that is used to bridge together particles and form large aggregates.
- pH Modifier — A reagent that changes the hydrogen ion concentration of the pulp, the purpose being to control particle charge or reagent effectiveness.

Particles naturally coagulate due to Van der Waals attraction if electrostatic repulsion is neutralized. Unfortunately, most minerals are negatively charged when dispersed in water, thus cationic coagulants are typically required. Older coagulants, which included inorganic salts such as NaCl, CaCl2, FeCl2, and Al2(SO4)3, have largely been replaced by manufactured polymers (liquid and dry, usually cationic) due to lower costs, less scaling, better coagula strength, and better dispersion. Coagulant dosage requirements vary widely from case to case and excessive additions can actually reverse charge and again induce repulsion (an optimum dosage exists - more is not always better). Flocculants, which adsorb strongly on particles, are usually based on polyacrylamide (which is nonionic) and its derivatives (which may be cationic or anionic). Flocculant dosage is normally adjusted to maintain recommended settling rates to ensure the thickener is kept pumped down.

The purpose of this lab is (i) to demonstrate the effects of coagulants and flocculants on water clarification and solids thickening and (ii) to determine the effects of different feed particle concentrations on coagula settling rate using a graduated cylinder test method. The information collected from the exercise will then be used to estimate the sizing requirements for a thickener.

Helpful Equations

Thickener Area (Coe and Clevenger, 1916)	$A = \frac{F}{V(\rho)}\left(\frac{100}{S_f} - \frac{100}{S_u}\right)$
Nomenclature	A = thickener area (ft^2) F = dry solids feed rate (lb/hr) S_f = feed percent solids (%) S_u = underflow percent solids (%) ρ = water density (62.4 lb/ft^3) V = settling rate (ft/hr)
Slurry Calculations	$Water\ TPH = Solid\ TPH\left(\frac{100}{\%Solids} - 1\right)$ $4\ GPM\ Water = 1\ TPH\ Water$ $Slurry\ GPM = k \times Solids\ TPH$ $k = 4\left(\frac{1}{Solids\ SG} + \frac{100}{\%\ Solids} - 1\right)$

Procedure

Part A – Settling Test Demonstration

1. Don all appropriate safety and personal protective equipment.

2. The laboratory instructor will demonstrate the graduated cylinder test method using several different sets of conditions. Record each condition and note any mechanisms that you observe during the test.

3. Based on your observations, please answer the discussion questions below before moving to the next section.

Part B – Settling Test

1. Don all appropriate safety and personal protective equipment.

2. Obtain three 1-liter graduated cylinders from the instructor. Label the cylinders A, B and C.

3. Place the following amounts of feed solids into each cylinder and fill with water to the 1,000 ml mark. Cylinder A = 25 gms, Cylinder B = 50 gms, Cylinder C = 100 gms.

4. Completely mix the contents in each cylinder by rotating the cylinder end over end at least 20 times. The air space should pass completely through the mixture during each rotation.

5. Obtain very small samples of dry coagulant (<1 gm) from the laboratory instructor.

6. Add a small amount of dry coagulant (i.e.., a few grains) and rotate the cylinder end over end 10 times. Repeat this procedure until successful coagulation is observed. (Be careful not to add too much coagulant as this will cause charge reversal and particle dispersion.)

7. After mixing, set the cylinder on a solid stable surface and begin recording the location of the mud level (i.e., interface between clarified water and settling solids) as a function of time. The following time intervals are recommended: 10, 20, 40, 80, 160, 320, and 640 seconds.

8. Plot the mud level data on the graph paper shown below. Repeat the procedure for all three cylinders containing different concentrations of feed solids.

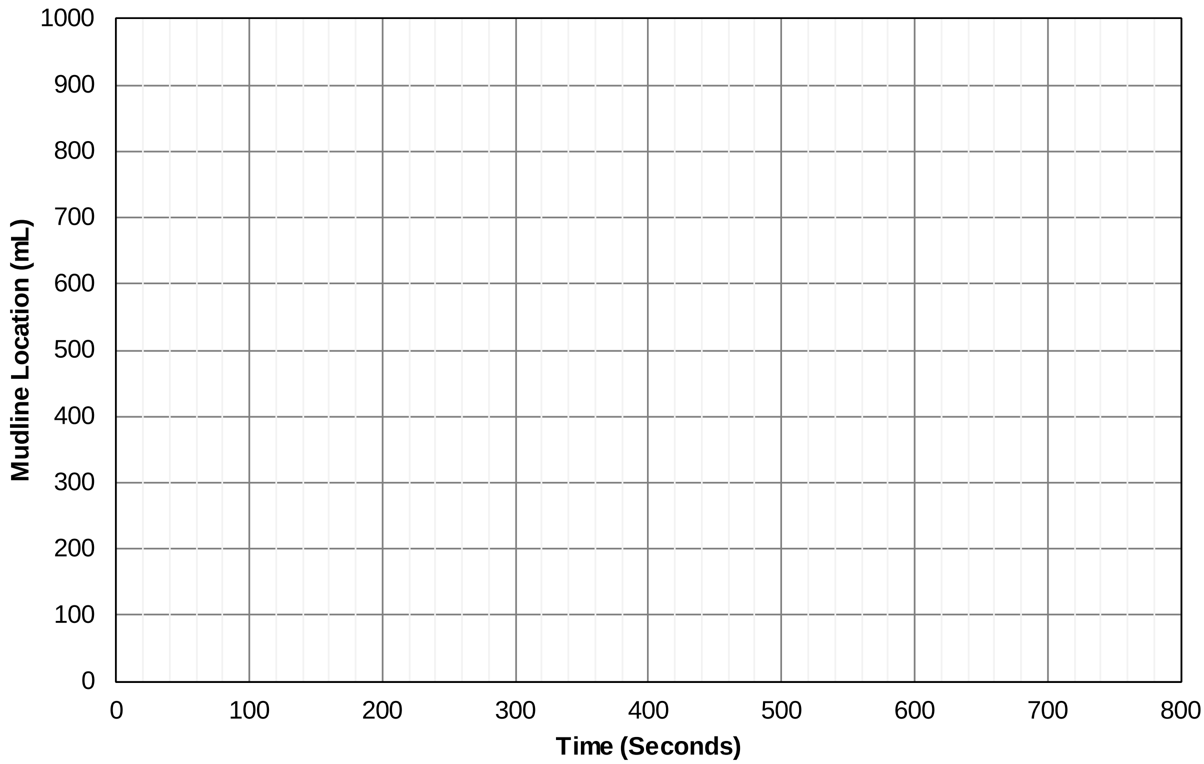
9. Measure the distance (in inches) between 0 and 1,000 ml on the graduated cylinder. Use this value to determine the initial "fast" and final "slow" settling rates. Record the values below.

Data Records & Calculations

Part A - Settling Test Demonstration

Test Condition	**Observation**
1. No chemical addition.	

Part B – Settling Test



Cylinder A: Fast Rate = __________ inch/min Slow Rate = __________ inch/min

Cylinder B: Fast Rate = __________ inch/min Slow Rate = __________ inch/min

Cylinder C: Fast Rate = __________ inch/min Slow Rate = __________ inch/min

Discussion Questions

Part A - Settling Test Demonstration

1. What does the coagulant do and how did the slurry respond?

2. What does the flocculant do and how did the slurry respond?

3. Does the order of dosing matter? Explain why or why not.

Part B – Settling Test

1. Which cylinders provided the best and worst clarity values? Please explain why

2. Choose a settling curve and use the data to design a thickener to treat 50,000 tons of dry solids (Solid SG = 2.7) per day with feed and underflow densities of 45% and 65%, respectively. Assume the Coe and Clevenger (1916) formula in the table above will provide an estimate of the required thickener area.

Estimated Area = __________ ft^2 Estimated Diameter = __________ ft

3. Please determine the flow rate (in GPM) and dry tonnage rate (TPH) that is entering as feed, exiting as clarified overflow and exiting as settled underflow?

Stream	**Water (GPM)**	**Solids (TPH)**	**Slurry (GPM)**
Feed			
Overflow			
Underflow			

Conclusions

1. What was the objective of this laboratory exercise?

2. What were your major findings?

3. What important fundamental concepts did you learn from the exercise?