**SLUDGE THICKENING**

Thickening is a procedure used to increase the solids content of sludge by removing a portion of the liquid fraction. To illustrate, if waste activated sludge, which is typically pumped from secondary tanks with a content of 0.8% solids, can be thickened to a content of 4% solids, then a fivefold decrease in sludge volume is achieved [1].

Thickening is generally accomplished by physical means including co-settling, gravity settling, flotation, centrifugation, gravity belt, and rotary drum [1].

The volume reduction obtained by sludge concentration is beneficial to subsequent treatment processes, such as digestion, dewatering, drying and combustion from the following standpoints:

1. Capacity of tanks and equipment required

2. Quantity of chemicals required for sludge conditioning

3. Amount of heat required by digesters and amount of auxiliary fuel required for heat drying or incineration, or both.

Volume reduction is very desirable when liquid sludge is transported by tank trucks for direct application to land as a soil conditioner [1].

**Thickening Techniques Used in Sludge Processes**

Most common techniques of thickening in sludge processing are given in Table 1.

 Table 1. Thickening Techniques Used in Sludge Processes [2].

|  |  |  |
| --- | --- | --- |
|  **Method**  | **Sludge type**  | **Frequency and performance**  |
| Gravitational settling  | Raw primary  | Very good results.  |
| Gravitational settling  | Raw primary and W.A.S  | Frequently used. Small facilities obtain 4-6% solids concentration. Not often used in large facilities.  |
| Gravitational settling  | W.A.S  | Not frequently used. Low solids concentration (2-3%)  |
| Dissolved Air Flotation (DAF)  | Raw primary and W.A.S  | Not frequently used. Results seem to gravitational settling  |
| Dissolved Air Flotation (DAF)  | W.A.S  | Frequently used. Good results obtained (3.5-5% solids concentration)  |
| Basket centrifuge  | W.A.S  | Limited use. Good results obtained (8-10% solids concentration)  |
| Solid-bowl centrifuge  | W.A.S  | Usage is increasing. Good results obtained (4-6% solids concentration)  |
| Gravity belt filter  | W.A.S  | Usage is increasing. Good results obtained (3-6% solids concentration)  |
| Rotary drum  | W.A.S  | Limited use. Good results obtained (5-9% solids concentration)  |

Location of the thickener in a wastewater treatment plant is important. If sludge is to be digested, thickening a blend of primary and waste activated sludge is a good practice. If these sludges are to be dewatered, then they should be thickened separately and mixed immediately before dewatering [3].

**Sludge Thickening vs. Dewatering**

Both are methods of solids concentration and volume reduction. Only the degree of volume reduction is different. Generally thickeners concentrate sludge at lower than 15% concentration, the dewatering units concentrate the sludge to higher than 15% concentration [3]. Thickened sludge still behaves as a liquid and can be pumped. However, the dewatered sludge generally behaves as a solid and can be trucked in most cases.

**Operation of a Thickener**

A thickener operates pretty much like a settling tank. The feed enters from the middle, are distributed radially, the settled sludge is collected from the underflow, the effluent exits over the weirs.

In a continuously operated thickener, there are different zones of concentration. The topmost dear zone is free of solids and comprises the liquid that eventually escapes over the weirs. The next zone is called the feed zone although this zone does not necessarily have the same concentration of feed solids. This zone is characterized by a uniform solids concentration. Below the feed zone is a zone of increasing solids concentration (from feed zone concentration to underflow concentration). This zone is compaction zone.

Sludge blanket is defined as the top of the feed zone. The height of this blanket is the main operational control that the treatment plant operator has over the thickener. By increasing the underflow rate, the operator can lower the blanket, and hence the solids residence time is lowered, throughput of solids is increased and the solids concentration in the underflow is decreased. The operator then would have a higher reserve volume in case there is an unexpected heavy sludge load coming. A high sludge blanket will make the underflow solids concentration high due to high solids residence time. One problem with this approach is the gas formation due to the anaerobic activity. The gas formed will cause the flotation of the solids in the thickener. Chemicals like chlorine (CI2) need to be added to inhibit the biological activity. A well operated thickener will have a solids recovery of about 95% [3].

**Design of Thickeners**

The thickening process takes place in a settling tank with long-enough solids retention time. For example in secondary clarifiers of activated sludge systems both clarification and thickening operations are carried out. Actually, the thickening of the sludge is a concern to the operator where he desires a high underflow solids concentration. So it is the general practice to design these processes for both thickening and clarification performance.

Similar to the digesters, there are two design approaches in thickeners too:

1. Design based on experience.

2. Design based on Iaboratory data.

**2. Design based on Iaboratory data**

*First Approach:*

It is the best technique if the Iaboratory data is available. Typical test is done by using a 1000mL-graduated cylinder. Sludge is mixed homogenously and let to settle in the cylinder. In seconds an interface separating the solids and the clear water on top is formed with a certain settling velocity. This velocity of the interface is measured with respect to time. Interface height is plotted against time and the zone settling velocity (ZSV) is calculated from the initial slope of the graph. The graph is given in Figure 1.

The velocity with which solids settle out will depend on the concentration of solids. Right after time zero, there are two interfaces moving towards each other. One from the bottom up due to the building up layers of sludge from the bottom, the other interface is moving down from top to bottom, this is the blanket of settling sludge, settling velocity, v. At time t2, these will meet and settling will slow down. Then the settling will cease over time and compaction begins [3]. Figure 2 shows the illustration of interfaces during settling test.









Procedure:

1. Determine the slope of the zone settling region (ZSV) (this is the settling velocity for clarification).

2. Extend the tangents from the ZSV region and compression region and bisect the angle formed to locate point 1.

3. Draw a tangent to the curve at point 1.

4. Knowns: Co, Ho, and select Cu, then make a mass balance

Cu.Hu = Co.Ho, calculate Hu from:



5. Draw a horizontal line from Hu until it intersects with the tangent line and determine tu. This is the time required to reach an underflow concentration.

6. Determine the area required for thickening (At)



where

Q = flowrate to the aeration tank excluding the recycle flow

R = recycled sludge flow

Q+R = total flow to the clarifier

1.5 = scale-up factor

7. Determine the area required for clarification (Ac)



Q = the effluent flow over the weir (same as above)

2.0 = scale-up factor

*"****Whichever area is larger will govern the design and will be the design area****."*

**References:**

[1] Metcalf and Eddy, 1997. Wastewater Engineering, Treatment, Disposal and Reuse. McGraw Hill, New York.

[2] http://web.deu.edu.tr/atiksu/ana58/bolum08.pdf

[3] Enve 422, Treatment and disposal of water and wastewater sludge, METU.

