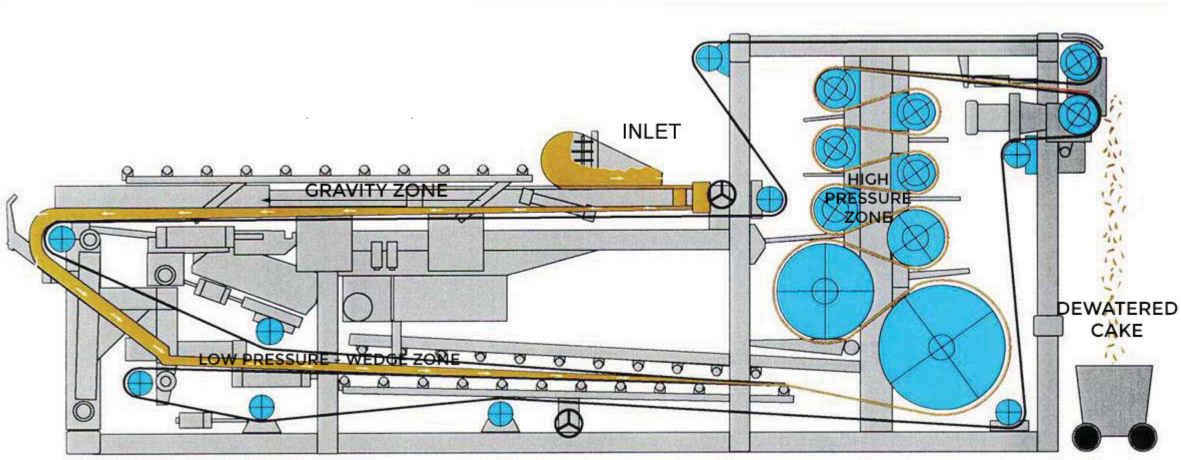
21. Solids Dewatering

- Dewatering, like thickening does not treat the sludge but it allows for a reduction in sludge volume by removing water.
- Thickening achieves about 10% or less solids content while dewatering is typically for increasing the solids content to between 15 to 30 percent.
- Sludge is dewatered to make it easier to handle and to reduce costs associated with elements related to accomplishing the end objectives with the sludge – land application, composting, drying, incineration or landfill.
- Dewatering involves conditioning the sludge with a polymer and subjecting it to a physical process such as belt filter press or centrifuge to remove the water.
- Reasons for sludge dewatering are:
  - Critical for sludge treatment options such as sludge drying and incineration.
  - Reduction in the weight of solids to be hauled – reducing hauling cost.
  - Reduction in the volume of sludge that needs to be handled
- More common sludge dewatering methods include:
  1. Belt Filter Press
  2. Centrifuge
- These are both mechanical methods and involve physically removing free water
- Both these methods involve conditioning of sludge with a cationic polymer which flocculate the solids - separating it from the water

21.1 Belt Filter Press

The belt filter press dewaters sludge by squeezing polymer conditioned sludge between a pair of belt filter fabric as these belts pass through a system of rollers. Belt filter press produces a dewatered product typically between 12% to 35% solids content.



Belt Filter Press

21.1.1 Principles of belt filter press operations

- Belt filter press utilizes two endless, porous belts (generally 0.7 to 3 meter wide) made from a synthetic material
- Polymer flocculated sludge is first introduced on the horizontal gravity zone of the press where free water is removed from the sludge by chicane assisted gravity filtration through the porous belt press fabric.

Gravity Zone - Chicanes

- From the gravity zone, the sludge enters the low pressure zone (wedge zone) in which the sludge is prepared for the upcoming high-pressure zone by evenly distributing the solids across the belt and gradually applying pressure
- In the high pressure zone the sludge is sandwiched between two belt press fabrics. As the belts with the sandwiched sludge passes over and under 6 to 12 tensioning rollers which progressively decrease in diameter. The applied pressure squeezes the water out from the sludge and is removed through the porous fabric.
- The filtrate is returned back to the front of the plant.
- The belts are washed continuously as they pass over wash boxes. The wash boxes are equipped with rotating brushes and water sprays and are primarily for keeping the belt press fabric pores open so water could easily filter through.
- Improper polymer dosage and excessive hydraulic loading can lead to a wetter sludge cake.
- The belts are operated at speeds that commensurate with the rate of solids loading and the type of sludge being dewatered. Lower belt speed would allow for better water removal. However, if if the belts speed is below the threshold for that particular sludge, belt press washout, which is characterized by sludge flowing over the sides of the belt can occur . Thus, the best belt speed is the slowest speed the belt can be operated without causing washout.
- The belts can be blinded - loose its porosity causing the water to stagnate/cause washout and not filter through, if excessive polymer is used or due ineffective belt washing.
- Solids capture rate and Percent cake solids produced are the most important belt press efficiency measurement parameters

21.1.2 Elements of the belt filter press

- belts
- wash boxes
- guiding and tensioning rollers
- chicanes
- doctor blades
- drive motor
- hydraulic unit
- polymer injection and mixing system

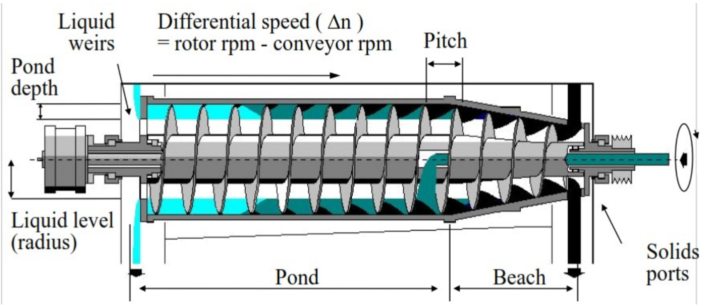
21.1.3 Belt press operational parameters

- belt filter width
- belt filter speed
- hydraulic loading
- belt tension
- washout
- filtrate quality
- solids capture rate

- polymer dosing rate (lbs polymer/dry ton solids)
- solids and hydraulic loading rates, and
- quantity and characteristics of the polymer used

21.2 Centrifuge

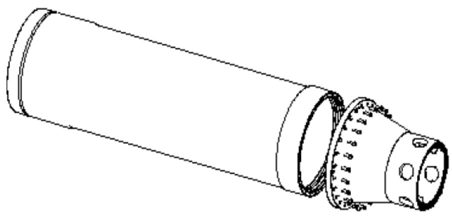
The centrifuge dewaters the sludge by subjecting a polymer conditioned sludge to strong centrifugal forces by rotating it in a bowl at high speeds. Centrifuges are used for dewatering solids in many different applications and wastewater solids dewatering being one them. Centrifuges also come in different configurations. The scroll conveyor (decanter) centrifuge is the more commonly used centrifuge design for wastewater sludge dewatering. It produces a dewatered product typically between 20% to 30% solids content. It should be noted that the centrifuge can also be utilized for sludge thickening.

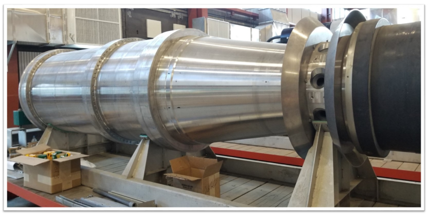


Centrifuge

21.2.1 Principles of centrifuge operations

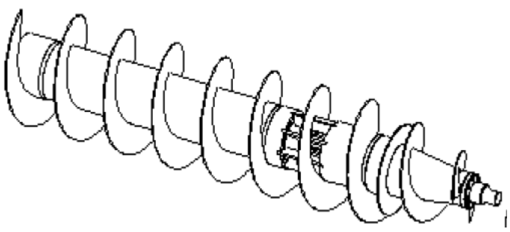
- The bowl of the centrifuge is cylindrical shaped with a tapered cone at one end. The bowl is designed to rotate at speeds of 1200 to 2400 RPM.





Centrifuge Bowl

- A screw conveyor - scroll is shaped to the bowl contour and carried on a central shaft or drum and it rotates independently from the bowl.



Centrifuge Scroll

- The polymer conditioned sludge is fed into the cylindrical portion of the bowl through a central feed pipe. Inside the bowl, the sludge is subjected to intense G forces around 3000 Gs by virtue of the bowl rotating at a high speed.
- As the bowl rotates, the water in the flocculated sludge is separated from the solids .
- The scroll rotates at a 5 to 15 rpm differential speed from the bowl. This differential speed causes the thickened sludge to be propelled along the bowl for towards its conical end. As the sludge is screwed up the cone it emerges from the liquid at the beach, is drained and pushed up to discharge ports.
- The separated water is discharged from the cylindrical (non-conical) end of the bowl. The depth of the water - pond depth, is controlled by adjustable weirs at the discharge end.
- The greater the pond depth improves the centrate quality and solids recovery but it reduces the drainage zone at the beach end resulting in wetter solids. The pond depth is altered using adjustable weirs.
- The centrate is returned back to the front of the plant

21.2.2 Elements of the Centrifuge

- bowl
- scroll
- beach
- adjustable weir
- differential gear box
- drive motor

21.2.3 Centrifuge operational parameters

- bowl speed
- differential speed
- pond height
- centrate quality
- solids capture rate
- polymer dosing rate (lbs polymer/dry ton solids)
- solids and hydraulic loading rates

21.3 Dewatering math problems

21.3.1 Calculation of solids recovery

Example Problems:
(a) Calculate amount of solids fed to the dewatering unit
(b) Calculate the amount of solids produced as part of the dewatered cake
(c) The ratio of the solids in dewatered cake to that in the feed times 100 will give you the solids recovery (solids recovery rate)

21.3.2 Calculation of dewatered cake volume

(a) First calculate the amount of cake solids produced in terms of weight per time.

(b) From the weight of the cake produced calculate the volume - from the cake density which is normally given

21.3.3 Hauling cost impact due to solids content change

(a) First calculate the amount of dry solids produced as part of the original wet cake solids percent
(b) Using the value of the dry solids calculate the wet cake weight with the new cake solids percentage
General formula for calculating net savings associated with change in cake solids content:

$$Savings = \frac{(New\ solids(\%) - Old\ Solids(\%))}{New\ solids(\%)} * Old\ Cost$$

So if the average cake dryness goes up from 20% to 26% and currently this utility is spending \$ 1,000,000 per year for biosolids hauling and disposal, their net savings will be:

$$\frac{(26\% - 20\%)}{26\%} * 1,000,000 = \$230,769$$

Example Problems

1. 12,000 ft^3 of anaerobically digested sludge containing 2.8% TS is dewatered in a centrifuge. The centrifuge yields 37 yd^3 of 26% of dewatered cake with a density of 73 lb/ft^3. Calculate the solids capture rate.
   Solution:
   $$lbs\ TS\ feed\ to\ centrifuge = 12,000 ft^3\ sludge * 7.48 \frac{gal}{ft^3} * \frac{(8.34 * 0.028 lbs\ TS)}{gal\ sludge} = 20,960 lbs\ TS$$
   $$lbs\ TS\ feed\ from\ centrifuge = 37 yd^3\ sludge * 27 \frac{ft^3}{yd^3} * \frac{(73 lbs * 0.26\ TS)}{ft^3\ sludge} = 18,961 lbs\ TS$$
   $$solids\ capture\ rate = \frac{18,961 lbs\ solids\ produced\ by\ centrifuge}{20,960 lbs\ solids\ fed\ from\ digester} * 100 = \boxed{90.4\% solids\ capture}$$
2. At a 60 GPM of 2.8% feed a belt press which has a 90% solids capture rate produces a 20% cake at 68 lbs/ft^3. How long would it take to fill a 3 yd^3 bin
   Solution:
   $$\frac{cake\ TS\ produced - lbs}{min} = \frac{60 gallons\ sludge}{min} * \frac{8.34 lbs\ sludge\ feed}{galllon} * \frac{0.028 lbs\ TS}{lb\ sludge} * 0.9$$
   $$= \frac{12.61 lbs\ TS}{min}$$
   $$\frac{ft^3\ cake\ produced}{min} = \frac{12.61 lbs\ TS}{min} * \frac{100 lbs\ cake}{20 lbs\ TS} * \frac{ft^3\ cake}{68 lbs\ cake} = \frac{0.927 ft^3 cake}{min}$$
   $$\frac{ft^3\ cake\ produced}{min} = \frac{12.61 lbs\ TS}{min} * \frac{100 lbs\ cake}{20 lbs\ TS} * \frac{ft^3\ cake}{68 lbs\ cake} = \frac{0.927 ft^3 cake}{min}$$
   $$Time\ required\ to\ fill\ the\ bin = \frac{min}{0.927 ft^3} * 3 yd^3 * \frac{27 ft^3}{yd^3} = \boxed{75 min}$$