Centrifuges for Dewatering and Thickening

Annual Class III & IV Workshop for Water & Wastewater Operators
July 25 & 26, 2018
Sludge Dewatering
Important Parameters

Separation performance
- efficiency
- throughput
- cake solids
- flexibility*

Emission
- sound
- odor
- aerosols (messiness)

Economics
- hauling costs
- energy consumption
- polymer consumption
- water consumption
- operator attention

*primary, mixed, 100% WAS, etc.
Cost of Treatment

Items to Consider

21% POLYMER COSTS
$3.00 / lb active substance
($1.20 / lb neat, 40% activity)

4% POWER COSTS
$0.06 - $0.12 / kWh

75% SLUDGE DISPOSAL COSTS
~$52.00+ / ton solids
## Performance Process

### Typical performance on different types of sludges

<table>
<thead>
<tr>
<th>Type of Sludge</th>
<th>Feed Solids (%)</th>
<th>Polymer (kg/Tonne dry solids)</th>
<th>Cake (% TS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary, Undigested</td>
<td>4-8</td>
<td>2-15</td>
<td>25-40</td>
</tr>
<tr>
<td>WAS, Undigested</td>
<td>1-4</td>
<td>7-15</td>
<td>16-25</td>
</tr>
<tr>
<td>Primary + WAS, Undigested</td>
<td>2-4</td>
<td>2-8</td>
<td>25-35</td>
</tr>
<tr>
<td>Primary + WAS, aerobic digested</td>
<td>1.5-3</td>
<td>7-15</td>
<td>16-25</td>
</tr>
<tr>
<td>Primary + WAS, Anaerobic digested</td>
<td>2-4</td>
<td>7-15</td>
<td>22-32</td>
</tr>
<tr>
<td>Primary Anaerobic Digested</td>
<td>2-4</td>
<td>4-6</td>
<td>25-35</td>
</tr>
<tr>
<td>WAS aerobic digested</td>
<td>1-4</td>
<td>10</td>
<td>18-21</td>
</tr>
<tr>
<td>Hi-temp Aerobic</td>
<td>4-6</td>
<td>10-20</td>
<td>20-25</td>
</tr>
<tr>
<td>Hi-temp Anaerobic</td>
<td>3-6</td>
<td>10-20</td>
<td>22-28</td>
</tr>
<tr>
<td>Lime Stabilized</td>
<td>4-6</td>
<td>7-12</td>
<td>20-28</td>
</tr>
</tbody>
</table>
## Performance
### Typical Performance Figures

<table>
<thead>
<tr>
<th>Sludge Type</th>
<th>A Feed Solids Conc. %</th>
<th>B Cake % Solids</th>
<th>C ppm Centrate</th>
<th>Solids Capture Efficiency</th>
<th>Polymer Dose Kg/T (active)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alum (low NTU raw water)</td>
<td>1 - 6</td>
<td>10-15</td>
<td>200-1000</td>
<td>Up to 99.9%</td>
<td>2 – 4</td>
</tr>
<tr>
<td>Alum (high NTU raw water)</td>
<td>1 - 6</td>
<td>20-25</td>
<td>50-1000</td>
<td>Up to 99.9%</td>
<td>1 – 2</td>
</tr>
<tr>
<td>Ferric and Lime treated</td>
<td>1 - 6</td>
<td>25-35</td>
<td>50-500</td>
<td>Up to 99.9%</td>
<td>1 – 2</td>
</tr>
<tr>
<td>Lime softening</td>
<td>3 - 10</td>
<td>50-60</td>
<td>100-1000</td>
<td>Up to 99.9%</td>
<td>0 – 1</td>
</tr>
<tr>
<td>Ferric hydroxide</td>
<td>1 - 6</td>
<td>15-25</td>
<td>100-1000</td>
<td>Up to 99.9%</td>
<td>1 - 3</td>
</tr>
</tbody>
</table>
WHAT DOES THIS REALLY MEAN?

- Sludge Type affects performance
- Projected Centrifuge Performance = \(0.5 \times (100 - \% \text{VS}) + 6\%\)
- Centrifuges will produce solids that are 3-8 percentage points drier than any other technology
- Example:
  - Belt Press produces 16%
  - Centrifuge achieves 21%
  - Reduction = 31%
### Advantages – Dewatering

Centrifuge vs. Other Technologies

<table>
<thead>
<tr>
<th></th>
<th>Centrifuge</th>
<th>Belt Press</th>
<th>Fan Press</th>
<th>Screw Press</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Operation</td>
<td>++</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Unsupervised Operation</td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>+</td>
</tr>
<tr>
<td>Odor Emission</td>
<td>++</td>
<td>--</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>High Dry Solids</td>
<td>++</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Varying Sludge Properties</td>
<td>++</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Hydraulic Capacity</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>Footprint</td>
<td>++</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Installed Power</td>
<td>0</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Polymer Consumption</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>--</td>
</tr>
<tr>
<td>Water Consumption</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manpower</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Service Interval</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>$</td>
<td>$$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td>Capital Investment</td>
<td>$$</td>
<td>$</td>
<td>$$$$</td>
<td>$$</td>
</tr>
</tbody>
</table>
Centrifuge Basics

Sedimentation Pool

Sedimentation by Gravity

Clarification Area = Pool Surface:

\[ A = l \cdot w, \]

A: Surface, l: Length, w: Width

Driving Force \( f = \) Gravity = 1 x g

Equivalent Clarification Area \( \Sigma = \) Driving Force \( f \times \) Surface \( A \)

\[ \Sigma = f \cdot A = l \cdot w \]
Centrifuge Basics

Continuously operating settling tank in the centrifugal field:
New Design Features
Technology Improvements over the last 20 Years

New design elements:

• Double Cone Scrolls
• Deep Pond Technology
• Fully Flighted Scroll with Axial Windows
• Dual Independent Drive Systems
• Centrate Energy Recovery

The end result is a more energy efficient user-friendly centrifuge.
Typical Modern Centrifuge Design Features

- Steep cone design (increased separation volume)
- Double Cone and Baffle Disk Intensive compacting (drier solids) and longer clarification area (cleaner centrate).
- Gentle product feed and acceleration
- Full flighted Scroll with axial flow windows (improve centrate flow/quality)
- Deep Pond Design (Better efficiency and compacted solids, more sludge treatable at same diameter bowl)
New Design Features
Double cone scroll with baffle disk
The double cone and baffle disc builds up a wall of solids that creates a deeper pond than a scroll without a baffle disc.

Benefits:

- Longer residence time = drier solids & cleaner centrate.
- Less energy consumed. Pond level closer to rotating axis.
Energy losses with continuous dewatering centrifuges are mainly due to the liquid and solid phase taking the rotary energy out of the decanter. The larger the distance to the rotary axle the more energy is lost.

Applied decanter design means reducing energy losses by bringing the overflow edge closer to the axle via smaller weir diameter.

State-of-the-art deep pond technology reduces specific energy consumption significantly:

- **Dewatering** as low as **0.2 kW/gpm**
  
  (0.9 kWh/m³)

- **Thickening** as low as **0.06 kW/gpm**
  
  (0.25 kWh/m³)

Deep Pond Design

Weir Radius
Sludge Thickening
Important Parameters

Separation performance
- efficiency
- throughput
- controlability
- flexibility*

Economics
- energy consumption
- polymer consumption
- water consumption
- operator attention

Emission
- sound
- odor
- aerosols (messiness)

* with and w/o polymer, primary, mixed, pure WAS, etc.
Mechanical sludge thickening can be achieved with various types of equipment.

- decanter centrifuges
- gravity belt thickeners (GBT)
- disk thickener
- screw thickener
- others (flotation, static)

Decanter centrifuges are a superior thickening technology, even for small and medium sized plants.

source of pictures: Huber SE and Gebr. Bellmer GmbH
Sludge thickening
Centrifugation instead of filtering

Separation and compression by centrifugal force

- allows operation without polymer
- optional polymer for cleaning up fines
- no total flocculation (GBTs, drums)
- no overdosing (polymer feed control)
- no negative influence of heavy polymer dosing
Sludge thickening
Advantages of thickening centrifuges

<table>
<thead>
<tr>
<th>Energy consumption (kW/cbm)</th>
<th>Separation efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>with poly</td>
<td>0.09</td>
</tr>
<tr>
<td>w/o poly</td>
<td>0.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real reference:</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4E-4/454 OSE decanter:</td>
</tr>
<tr>
<td>Sludge flow: 88 gpm</td>
</tr>
<tr>
<td>concentration: 0.7 – 0.9 %</td>
</tr>
<tr>
<td>underflow:</td>
</tr>
<tr>
<td>Polymer consumption: none or 1.0 lb/t ds</td>
</tr>
</tbody>
</table>
Sludge thickening
Advantages of thickening centrifuges

Thickening centrifuge

- Very low polymer use
  1.0 – 4.0 lb/t dss (or even none)
  compared to
  8.0 – 16.0 lb/t dss (other thickeners)

- Very high capture rate
  99 % (with polymer)
  compared to
  80 – 90 % (other thickeners)

- Very small space requirements

- Unattended operation (24/7)

- Low energy usage

Thickening centrifuge with thickened sludge sensor

- Thickened sludge concentration remains constant (e.g. 6.0 ± 0.1 %)

- Optimized digestion leads to
  - Higher gas yield
  - Better dewaterability of digested sludge

- Fluctuating feed concentrations are automatically handled by
  controlled thickened sludge concentration
  (e.g. during torrential downpour)

- No manual adjustment
Sludge thickening
Advantages of thickening centrifuges

Thickening centrifuge protects plant staff

- No aerosol and odor emission
  (decanter is an enclosed system)

- Very quiet operation (low g-force)
Sludge thickening
Advantages of thickening centrifuges

Thickening centrifuge with thickened sludge sensor
- Automatic adjustment of differential speed to match any set point of thickened sludge concentration

Thickening centrifuge with feed sludge sensor
- Automatic adjustment of polymer flow to current solid feed rate
  - No overdosing (cost savings)
  - No underfeeding (separation efficiency)
Sludge thickening
Advantages of thickening centrifuges

Thickening centrifuges last forever

- more than 100,000 operating hours and 20 years before first scroll rebuild

Landshut, Germany; 1 unit Z53-4/454 OSE
Sludge thickening
Advantages of thickening centrifuges

- low specific energy consumption
- reasonable price
- small footprint with high performance
- no water consumption during operation, only needed during shutdown
- no odor emission
- no health endangering cleaning necessary
- minimal need for supervision and control through continuous and automatic operation (up to 24/7)
- no or minimal polymer consumption
- all product wetted parts in stainless steel
- advanced wear protection and solid construction leads to long service life
### Sludge thickening
Advantages of thickening centrifuges

<table>
<thead>
<tr>
<th></th>
<th>OSE</th>
<th>flotation</th>
<th>rotary drum thickener</th>
<th>gravity belt thickener</th>
<th>static thickener</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>24/7 without supervision</strong></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>no odor emission</strong></td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>manual cleaning</strong></td>
<td></td>
<td></td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td><strong>different sludge properties</strong></td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td><strong>dryness of sludge adjustable</strong></td>
<td>++</td>
<td>--</td>
<td>--</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td><strong>footprint</strong></td>
<td>++</td>
<td>0</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>water consumption</strong></td>
<td>+</td>
<td>+</td>
<td>--</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td><strong>aeration</strong></td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>--</td>
<td>++</td>
</tr>
<tr>
<td><strong>polymer costs</strong></td>
<td>($)</td>
<td>$</td>
<td>$$$$</td>
<td>$$$</td>
<td>($)</td>
</tr>
<tr>
<td><strong>invest (machine)</strong></td>
<td>$$$</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$$$</td>
</tr>
</tbody>
</table>
The thickening centrifuge is an **economic** alternative – even for **small and medium sized plants**!
Sludge thickening
Marietta, OH

1 unit C5E-4/454 OSE
New Design Features
Full flighted scroll with axial flow windows

- New axial flow windows (only HTS scrolls)
- Still full flighted scroll blades
Dual Independent Drives

State-of-the-art technology invented by Flottweg.

Features:

- **Automatic** and **unattended** operation via torque control
- Highest **efficiency** and **reliability**
- Lower installed HP
- Small space requirement
- Independent scroll and bowl operation
- Standard **off-the-shelf** motors and frequency inverters
Centrate Energy Recovery System
Working Principle

How does it work?
### Centrate Energy Recovery System

**Working Principle**

Traditional design

<table>
<thead>
<tr>
<th>Traditional design</th>
<th>New design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrate is discharged straight into the housing.</td>
<td>Centrate is redirected and tangentially discharged into the housing.</td>
</tr>
<tr>
<td>Rotational energy of the centrate is lost!</td>
<td>Rotational energy is recovered!</td>
</tr>
</tbody>
</table>
Centrate Energy Recovery System

... save up to 20% additional energy by using centrate energy with Recuvane®
Centrate Energy Recovery System
Reduced Energy Consumption

- **Deep pond design**: reduces energy consumption by 25-30%

- **Dual Independent Drives**: lower installed HP and reduces energy consumption compared to hybrid, hydraulic or back drives

- **Centrate Energy Recovery**: reduces energy consumption by 20% by using centrate energy
Types of Installations

Single units

2 unit C5E-4/454 HTS
Types of Installations
Trailer mounted unit
Types of Installations
Skid mounted unit

1 unit C5E-4/454 HTS
QUESTIONS?
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