Selecting the right Equipment for your Sludge

Testing in the Lab

Charles Laughton - Euroby Limited
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- Product parameters at a glance
- Sedimentation
- Spin test
- Analytical methods
- Select the right machine
- Estimation of expected performance in sewage sludge dewatering
Product Parameters

- Difference in density between solid and liquid
- Viscosity of the liquid
- Particle diameter and size distribution
- Shape of the particles
- Surface roughness of the particles
- Solids concentration in the feed
- Residue / loss on ignition
  - content of inorganic or organic components
- Compressibility of the sediment
- Formation and stability of flocs
- Additives and their characteristics
  - Flocculation aids, emulsion breakers, fining agents, etc.
The interaction of these forces results in the sedimentation velocity, which is crucial for the separation efficiency of the centrifuge.
Sedimentation Theory

Resistance Force
\[ W = \frac{1}{2} \rho_l \cdot v_{rel}^2 \cdot \pi/4 \cdot x^2 \cdot c_w \cdot \text{Re} \]

Pressure Force (Bouyancy)
\[ P = \frac{\pi}{6} \cdot x^3 \cdot \rho_l \cdot g \quad \text{(or } r \cdot \omega^2 \text{)} \]

Field Force (Gravity)
\[ F = \frac{\pi}{6} \cdot x^3 \cdot \rho_s \cdot g \quad \text{(or } r \cdot \omega^2 \text{)} \]

The Equilibrium of Forces
\[ (W + P - F = 0) \]

Using \( c_w = 24/\text{Re} \) (Laminar Flow) and \( \text{Re} = v_{rel} \cdot x / \nu \)

Results in the Stokes Sedimentation Velocity:
\[ W_{st} = \frac{(\rho_s - \rho_l) \cdot x^2 \cdot g}{18 \cdot \eta} \quad \text{(or } r \cdot \omega^2 \text{)} \]
Analytical Method: Spin Test
Results obtainable by spin test:

- Composition of the product in volume %
- Number of individual phases
- Separation behavior of the product, qualitative
- Compression behavior in multiple tests with different spin time
- Compactness of the sediment, qualitative

Results not obtainable by spin test:

- Composition of the product in weight %
- Capacity of the decanter or separator
- Achievable cake dryness of a decanters or separator
- Resistance of construction materials
<table>
<thead>
<tr>
<th>Sample from</th>
<th>Parameter</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>solids cake, feed</td>
<td>TS = total solids</td>
<td>Dry residue, i.e. including dissolved substances in weight %</td>
</tr>
<tr>
<td>centrate, feed</td>
<td>TSS = total suspended solids</td>
<td>Undissolved solids after filtration using glass fiber filter, in weight %</td>
</tr>
<tr>
<td>feed, solids cake</td>
<td>VSS = volatile suspended solids</td>
<td>Content of organic volatile substances, in weight %</td>
</tr>
<tr>
<td>feed, solids cake</td>
<td>Residue on ignition (RI) RI + VSS = 100%</td>
<td>Content of inorganic, mineralic substances (ash content) in weight %</td>
</tr>
<tr>
<td>feed (biological sludge)</td>
<td>SVI = sludge volume index</td>
<td>Sedimentation behavior in a funnel</td>
</tr>
<tr>
<td>feed, centrate</td>
<td>Chemical oxigen demand (COD)</td>
<td>Organic load in a waste water</td>
</tr>
<tr>
<td>feed</td>
<td>CST = Capillary Suction Time</td>
<td>Drainage capability of a sludge</td>
</tr>
</tbody>
</table>
## Vegetable oil and animal fat

<table>
<thead>
<tr>
<th>Sample from</th>
<th>Parameter</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>feed, centrate</td>
<td>Solids content</td>
<td>Undissolved solids after filtration in weight %</td>
</tr>
<tr>
<td>solids cake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>feed, centrate</td>
<td>water content</td>
<td>Karl-Fischer test. Free and bonded water in weight %.</td>
</tr>
<tr>
<td>solids cake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>feed, centrate</td>
<td>volatile substances</td>
<td>Water and volatile components together</td>
</tr>
<tr>
<td>solids cake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>solids cake</td>
<td>oil content acc. to Soxleth</td>
<td>Oil content of a sample based on weight of sample or dry substance in weight %</td>
</tr>
</tbody>
</table>
# In-House Analysis

<table>
<thead>
<tr>
<th>Mineral oil and oil sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample from</strong></td>
</tr>
<tr>
<td>feed, oil discharge</td>
</tr>
<tr>
<td>feed, oil discharge solids cake</td>
</tr>
<tr>
<td>feed, oil discharge solids cake</td>
</tr>
<tr>
<td>water discharge</td>
</tr>
<tr>
<td>feed, oil discharge solids cake water discharge</td>
</tr>
</tbody>
</table>
In-House Analysis

Other Applications:

- Tar
- Proteins
- Wheat starch
Definition of the Spin Index

The spin index is the quotient of the sediment content of a suspension and the content on suspended solids:

\[
\text{Spin index} = \frac{\text{Sediment Content of the Suspension} \ (% \ v/v)}{\text{Content of suspended solids} \ (% \ w/w)}
\]

The sediment content is analyzed by centrifugation in a spin tube of 15 ml volume for 5 minutes at 1000 x g.
External Analysis

- Particle size
- Particle size distribution
- Viscosity
- Specific gravities
Product Overview

- Decanter
- Tricanter®
- Sedicanter®
- Sorticanter®
- Belt press
- Systems
- Disk stack centrifuge
Select the Right Machine

- Feed Solids Concentration in Vol.%

- Particle Diameter
  - 100 mm
  - 10 mm
  - 1 mm
  - 100 μm
  - 10 μm
  - 1 μm
  - 0,1 μm

- DECANTER
- PRESS
- SEDICANTER
- DISC STACK CENTRIFUGE
Dewatering of Sewage Sludge

Estimate the achievable cake dryness
- based on residue on ignition (ash content or VSS)
- based on spin index

The parameters, ash content (VSS), spin index, CST value, etc. are also suitable to figure out if the sludge characteristics have changed.
Cake Dryness based on Residue on Ignition

Expected Cake Dryness Based on Residue on Ignition

Residue on Ignition [% w/w] vs Cake Dryness [% w/w]
Estimation of the achievable cake dryness of sewage sludge based on the spin index
Activated or surplus sludge:
Cake dryness as a function of residue on ignition (ash content)
Activated or surplus sludge:
Cake dryness as a function of the spin index

Spin index

Cake dryness (w/w) %

Expected Cake Dryness
Expected Cake Dry Solids

Digested sludge:
Cake dryness as a function of the residue on ignition
Digested sludge:
Cake dryness as a function of the spin index

Graph showing the relationship between cake dryness (w/w) % and spin index.
Expected Polymer Consumption

Digested sludge:
Polymer consumption as a function of the residue on ignition (ash content)
Expected Polymer Consumption

Digested sludge:
Polymer consumption as a function of the spin index
Next Steps

- Send us your sludge samples.
- We will evaluate these and provide a test report (in most cases free of charge).
- Carry out pilot scale tests for reliable scale up.
- Carry out full scale tests using equipment from our rental fleet.
- Provide training days for maintenance and process operation at Euroby’s training centre or on-site.
THANK YOU
Selecting the right Equipment for your Sludge

Rick Hallam for Euroby Limited
Sludge Dewatering Options

Separation - Decanter

Filtration – Filter Press
Decanter Centrifuge

Schematic of Decanter

- Feed
- Solids discharge
- Liquid discharge by gravity
C- Series

- **Designed specifically for Treatment of Sludge**
  - Improved Bowl design
  - Control system
  - Simp drive system
  - On site replaceable wear parts
  - RecuVane power reduction (up to 30%)
- **Continuous unmanned operation**
- **Low whole life cost**
- **Low maintenance cost**
- **Compact Footprint**
- **Fully automatic operation**
  - Sludge density monitoring
- **Capable of producing a cake without full chemical treatment**
- **Excellent odour containment**
- **Sludge Thickening a viable option**
## Technical Data Centrifuges:

<table>
<thead>
<tr>
<th>Type</th>
<th>C5E-4/454 HTS</th>
<th>Z5E-4/454 HTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowl Diameter (mm)</td>
<td>570</td>
<td>530</td>
</tr>
<tr>
<td>Diameter/Length Ratio</td>
<td>1 / 4</td>
<td>1 / 4</td>
</tr>
<tr>
<td>Bowl Speed (rpm)</td>
<td>3100</td>
<td>3500</td>
</tr>
<tr>
<td>G- Force (x g)</td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td>Suspension Volume (l)</td>
<td>335</td>
<td>240</td>
</tr>
</tbody>
</table>

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C5E-4/454 SP 4.12

Z5E-4/454 SP 4.12
Comparison: C5E vs. Z5E

Spec. Power Demand vs. Flow Rate

- C5E
- Z5E
Comparison: C5E vs. Z5E

Cake Dryness vs. Flow Rate

- C5E
- Z5E
Comparison: C5E vs. Z5E

Spec. Polymer vs. Flow Rate

- C5E
- Z5E
RECOVERY
10-20 % reduced power consumption by using energy remaining in the centrate.

VANE
guided discharge of the centrate easy to retrofit (similar to weir plates)
variable pond depth (eccentric screws)
**Old Design**
Centrate discharged directly into the Housing: Energy is Lost

**New Design**
Centrate is guided and discharged tangentially: Energy is Recovered

**Flottweg C-series**
Centrate discharge with RECUVANE
C7E Centrifuge

Centrate discharge, Vibration sensor and Bearing block with Temperature sensor
C7E
Tests at WWTP Stammheim, Cologne and WWTP Ruhleben, Berlin
Energy consumption (bowl and scroll)

Flow-rate sludge [m³/h]

Flow-rate sludge [gpm]

Spec. energy consumption [W/m³]

Spec. energy consumption [W/m³]

Additional 20% reduction of energy consumption
Small Footprint

30% Lower energy

Lower Maintenance Costs

Lower Whole Life Costs

Thickening Becomes Viable
• Manual or fully automatic operation
  • Auto cloth washing
  • Auto cake discharge
• Range from 470mm sq to 2m sq
  • Recessed plates
  • Membrane plates
• Higher pressure of operation
• Batch operation
• Process options
  • Filter cake washing
  • Air blowing
Filtration Cycle

1-Initial position
2-Filtration
3-Membrane squeezing
4-Core blow
5-Membrane decompression
6-Cake discharge

Membrane squeezing sketch
Each machine supply options

- Hydraulic power pack for opening and closing
- Hydraulic drip trays
- Photo electric safety light curtains
- Selected Filter Cloths
- Automatic cloth washing – 110 bar
- Membrane squeeze with water, typical 10 to 15 bar up to max 60 bar
- Local control panel.
- Valve manifold
Filter Press

Drip trays

Cake Discharge
Automatic cloth washing
Conclusion

Points for consideration

- Type of sludge
- Volume of sludge per day
- Hours of operation per day
- Chemical addition, pre treatment, cost
- Space availability
- Feed pressure
- Down time (discharge time)
- Maintenance requirements
- Power consumption
- Washwater consumption
- Output requirements
  - Cake dry solids
  - Filtrate / Centrate clarity
Thank you from euroby