Thermal Hydrolysis Comes to Texas!

Samir Mathur PE, BCEE
CDM Smith

WEAT E&I Workshop
July 15, 2015
Presentation Outline

• Thermal Hydrolysis fundamentals
• Digestion fundamentals
• TRA CRWS WWTP Solids Improvements
• Project status and considerations
Thermal Hydrolysis Fundamentals
Thermal Hydrolysis is a process by which sludge is heated and pressurized with the purpose of reducing organic solids to make them more readily biodegradable.....

In other words, it’s a pressure cooker.
What is Thermal Hydrolysis?

- TH is a high pressure steam pre-treatment for anaerobic digestion
- Disintegrates cell structures/organic materials
- Dissolves naturally occurring cell polymers (exopolymeric substances-EPS), a form of protein, into an easily digestible feed for anaerobic digestion
THP Uses Heat and Pressure to Rupture Cells
Thermal Hydrolysis Process – Pre-Treatment Before Anaerobic Digestion
THP is a Pre-digestion Conditioning Process

- Conditions sludge feed to digestion to improve biodegradability
- Changes thixotropic properties of sludge
- Allows doubling of the load to conventional digestion
- Creates a Class A stabilized product
Meeting Class A Sludge Requirements

• Two part Class A treatment requirements (per 40 CFR Part 503)
  – Controls to reduce pathogens in treated sewage sludge (biosolids).
  – Reduce the ability of the treated sewage sludge to attract vectors (insects and other organisms).

• Thermal Hydrolysis will provide pathogen reduction (inactivation) through time and temperature (50 deg C for >20 min required and 165 deg C for 20 min provided)

• Vector attraction will be provided by anaerobic digestion to achieve a minimum of 38% reduction in volatile solids.
Benefits of Thermal Hydrolysis

• Less digestion capacity (fewer tanks, smaller footprint)
• Class A biosolids product
• Improved digestion efficiency
• Reduced disposal volume
• Improved biogas production
Thermal Hydrolysis
Primary Suppliers of THP Systems

Cambi

Kruger
Thermal Hydrolysis Process - Cambi

**Raw sludge**
- 14-18% DS
- 97°C 1.5 hr

**PULPER**
- homogenized sludge
- 11 bar

**REACTOR**
- 165°C 6 bar 20 min
- hydrolyzed sludge
- 1.5-2 bar
- 102°C 1.5 hr

**FLASH TANK**
- Recycled Steam
- Process gases (to digester)
- 8-12% DS

**Digester**
- 102°C 1.5 hr
- 11 bar
Thermal Hydrolysis Process - Kruger Exelys

Exelys™ thermal hydrolysis LD configuration (image courtesy Kruger)
CAMBI and Kruger Similarities/Differences

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Heat sludge to 320°F+</td>
<td>• Pre-Dewatering Solids Range (15%/&gt;22%)</td>
</tr>
<tr>
<td>• Require steam for sludge heating</td>
<td>• THP Process Flow (Continuous batch/Continuous plug flow)</td>
</tr>
<tr>
<td>• Intensive systems</td>
<td>• Lysis method (Heat+pressure+ flashing/Heat+pressure)</td>
</tr>
<tr>
<td>• Mechanically</td>
<td>• Total process time (Up to 4.5 hours/30 mins)</td>
</tr>
<tr>
<td>• Control/monitoring</td>
<td>• Digester HRT Avg Annual (15 days/22 days)</td>
</tr>
<tr>
<td>• Sludge screening requirements</td>
<td>• Digester HRT Max Month (12 days/15 days)</td>
</tr>
<tr>
<td>• Require downstream digestion for VAR</td>
<td>• VSR at Annual Avg (60/57)</td>
</tr>
<tr>
<td>• Limited operator requirements</td>
<td></td>
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</table>
## THP Installation Comparisons

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Overseas Facilities</th>
<th>United States Facilities</th>
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<tbody>
<tr>
<td>Cambi</td>
<td>&gt;30 Operating</td>
<td>1 startup</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 in Design/Bid Stage</td>
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<tr>
<td>Kruger Exelys</td>
<td>1 Operating</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>2 in Construction</td>
<td></td>
</tr>
<tr>
<td>Kruger BioThelys</td>
<td>7 Operating</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>1 in Design</td>
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</table>
Digestion Fundamentals
Basics of Anaerobic Digestion

- Environment deprived of dissolved oxygen and nitrates
- Mesophilic digesters 90 – 100 degrees F
- Thermophilic digesters 120 – 135 degrees F
- Pathogen Reduction via time and temperature (15 days at 90 – 135 degrees F)
- Vector Attraction Reduction accomplished by volatile solids reduction > 38%
Basics of Anaerobic Digestion

- Process primary sludge, waste activated sludge, or combination
- Biodegradation of volatile solids to methane and carbon dioxide
- Energy producing – biogas
- High solids concentration is not a problem
- Typically at mesophilic temperature (95-100°F)
- Challenges – Foaming, Optimization, Gas quality
Types of Digesters

- Conventional Digesters
- Tall Cylindrical Digesters
- Egg Shaped Digesters
Digester Cover Options

- Submerged Fixed Covers
- Fixed Steel Digester Covers
- Floating Covers
- Gas Storage Covers
- Membrane Gas Storage Covers
Submerged Fixed Cover Design

Advantages:
- Significant increase in digester volume
- Suitable for any mixer technology
- Can be designed for higher digester gas pressures (> 30-in w.c.)
- Minimal maintenance required
- Low heat loss coefficients (0.21 to 0.28)

Disadvantages:
- High Capital Cost
- Longer construction period

Enclosed cover eliminates odor and foam release
Small gas/liquid interface reduces corrosion
Maximize Volume
Foam & scum suppression
Gas Withdrawal
~ 8 Feet

Submerged Fixed Digester Cover
Fixed Steel Cover Design

Photo courtesy OTI
Floating Covers

Two different types of Floating-type covers:

- Rest directly on the liquid surface (Downes Style)
- Rest on side skirts and float on the gas (Wiggins Style)
Gasholder Cover/Membrane Gasholder Cover

Wiggins Style Cover

DyStor® Cover at Buckman WWTP
Jacksonville, FL

(2) Membrane Covers – JDV Equipment
St. Margarethen, Austria
## Digester Cover Comparison

<table>
<thead>
<tr>
<th></th>
<th>Gas Storage</th>
<th>Gas Pressure</th>
<th>Capital Cost</th>
<th>Heat Loss</th>
<th>Required Maintenance</th>
<th>Mixing System Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Submerged</strong></td>
<td>Low</td>
<td>High +</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
</tr>
<tr>
<td><strong>Fixed</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>Steel</strong></td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>No</td>
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<tr>
<td><strong>Floating</strong></td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Some</td>
</tr>
<tr>
<td><strong>Membrane</strong></td>
<td>High +</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Gasholders</strong></td>
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Digester Mixing Purposes

• Mix raw sludge with established digester biomass
• Mix hot sludge with cold sludge
• Keep grit in suspension and prevent settling in digester cone
• Mix top layer of digester and prevent foaming / scum formation
Digester Mixing Technologies Overview

- Pumped Recirculation Systems (JetMix™, Rotamix®)
- Draft Tube Mixers
- Gas 'Cannon' Mixing Systems
- Eimco LM™ (Linear Motion) Mixers
Pumped Recirculation Systems

Manufacturers: JetMix™ (Siemens) & RotaMix® Vaughan Co. Inc

Advantages:
- Mixing chopper pumps easily accessible for maintenance
- Scum mixing nozzles can be installed to ‘knock down’ foam
- No tank entry required for routine maintenance

Disadvantages:
- Any maintenance of mixing nozzles requires complete dewatering of tank
- Wear of chopper pump impeller & cutting blades
- High energy demands
- Suitable location to install chopper pumps
Draft Tube Mixing Systems

Internal Mixers

External Mixers

Courtesy OTI
Draft Tube Mixing System

Manufacturers: WesTech, Eimco, & OTI

Advantages:
- Good mixing ability w/ minimal scum & foam build-up
- Maintenance can be performed without taking digester out of service
- Redundant mixing capability
- Little chance of mixer clogging with rags

Disadvantages:
- Potential plugging of draft tube with rags & fibrous material
- Lower bearing replacement is required every 5-7 years
- Fairly energy intensive (~ 75 Hp per digester)
- Sensitivity to liquid level fluctuations
- External mixers may be only viable options for some digester cover options
Gas ‘Cannon’ Mixing Systems

Manufacturers: JDV Equipment, Walker Process, Degremont

Major System Components:
- Internal draft tubes, each 30-48-inch dia.
- Gas compressor (40 – 60 Hp)
- Gas piping & gas handling equipment

Advantages:
- Energy efficient
- Redundant mixing capability

Disadvantages:
- Does not provide good top-mixing, which can increase digester foaming issues
- Digester gas compressors can be a maintenance issue
- Potential gas-seal issues
Linear Motion (LM™) Mixers
New Digester Mixing Design from Eimco & Enersave Fluid Mixers™

Advantages:
- Much lower power required (approx. 12.5 Hp per tank)
- Lowest mixing capital cost

Disadvantages:
- Mixing effectiveness in question
- Unproven technology: three digester installations in operation since Dec. ‘03
- Bearing and gearbox failures
## Mixing Comparison

<table>
<thead>
<tr>
<th>Pumped Recirculation</th>
<th>Capital Cost</th>
<th>Energy Usage</th>
<th>Required Maintenance</th>
<th>Years in Use</th>
<th>Cover Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>10-20 yrs</td>
<td>No</td>
</tr>
</tbody>
</table>

| Draft Tubes          | High         | Medium       | Medium               | 20-30 yrs    | Yes              |

| Gas ‘Cannon’ Mixing  | Low          | Medium       | Medium               | > 40 yrs     | Yes              |

| Linear Motion Mixers | Low          | Low          | ?                    | ~ 4 yrs      | Yes              |
TRA CRWS WWTP Solids Improvements
Trinity River Authority (TRA)

• TRA is a watershed authority covering Northern Texas to the Gulf of Mexico, providing water and wastewater municipal services.

• Four WWTPs with the largest being Central Regional Wastewater System Facility (CRWS), commissioned in 1959

• 162 MGD facility
• Serves 1.2 million people in City's of Irving, Western Dallas & Grand Prairie

• Advanced WWTP
• Class AB biosolids using DAFs, GTs, GBTs, BFPs, FPs and lime.
TRA Solids Master Plan

- Completed in 2010

- Phased implementation

- Convert lime stabilization to digestion
  - Thermal hydrolysis recommended
Solids Management Improvements

• Multi-Phased project called Solids Management Improvements (SMI)

• Intent & objective
  – Replace existing aging equipment
  – Make use of existing infrastructure
  – Install state of art process equipment
  – Reduce solids volume to control costs
  – Produce Class A sludge (biosolids)
Current TRA Solids Handling Process

Primary Sludge → Primary → Aeration → Secondary → Thickening → Lime → Class “A” Land Application → Landfill

Thickening → Dewatering
Proposed Solids Handling Process

- Primary
- Solids Screening
- Thickening
- WAS
- Pre-Dewatering
- Thermal Hydrolysis
- Mesophilic Digestion
- Biogas
- Dewatering
- Class "A" Land Application

- Landfill
- Compost
- Soil Amendment
Benefits of Thermal Hydrolysis Process

- Class A product
- Higher volatile solids destruction
- Higher biogas production
- Ability to feed digesters at higher solids concentration
- Improved sludge dewaterability
How Well Will This Process Work For TRA CRWS?

- Confirm benefits of thermal hydrolysis Process for TRA
- Testing conducted at Virginia Tech University by Dr. John Novak
Results
Average Total Solids Reduction

% TSR

Phasel

Phasell

Control
TH-37
TH-42

33.3 ± 0.2
48.6 ± 0.2
42.6 ± 0.2

34.4 ± 0.2
31.0 ± 0.2
31.2 ± 0.2
Total Ammonia Concentration

- Feed: Control 200, TH-37 364
- Phasel: Control 294, TH-37 1340, TH-42 1291
- Phasell: Control 600, TH-37 1573, TH-42 1738
Specific Gas Production

[Bar chart showing gas production (L/g of VS destroyed) for different treatments.]

- Phasel:
  - Control: 13.38 L/g
  - TH-37: 15.79 L/g
  - TH-42: 17.25 L/g

- Phasell:
  - Control: 11.7 L/g
  - TH-37: 14.86 L/g
  - TH-42: 15.42 L/g
Overall pH

- **Phasel**
  - Control: 7.14
  - TH-37: 7.46
  - TH-42: 7.61

- **Phasell**
  - Control: 7.12
  - TH-37: 7.71
  - TH-42: 7.61
TVOSC Odor Analysis
## Dewatering Data

<table>
<thead>
<tr>
<th></th>
<th>Total Solids (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control Digester</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>24.5</td>
</tr>
<tr>
<td><strong>Thermal Hydrolysis Digester</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35.6</td>
</tr>
<tr>
<td></td>
<td>38.6</td>
</tr>
</tbody>
</table>
Testing Summary

• Thermal hydrolysis would be an effective process for TRA
  – 9 to 10% increase in VS destruction
  – Ammonia production is not inhibitory, even at 42°C, resulting in lower cooling costs
  – Low odor product can be expected
  – Almost 10% increase in solids concentration after dewatering

• Results are similar to previous testing at VT for Blue Plains WWTP
Project Status
Current Status – Preliminary Design
Current Status – Preliminary Design
Current Status – Preliminary Design
Project Considerations
Maximize Use of Existing Infrastructure
Sidestream Treatment and Struvite
Phosphorus Management Alternatives

- Alternative 1 - Struvite Harvesting from Sidestreams
- Alternative 2 – Struvite Harvesting from Digested Solids
- Alternative 3 – Chemical P Precipitation
  - Alum/Ferric
Construction Sequencing
Complete New BFP Installation and Startup

Operate GBTs 1-5 with New Blend Tank
Tie-in GBT 6

Demolish Ash Silos, Filters, etc. (Aug-Sep 2016)

Install Temporary Piping (WAS from 13, 13A, 13B; Chilled Water, GBT Filtrate, etc.)

Complete Construction of PS 15 Superstructure
Install Screens
Install Electrical and Controls

Demolish Exist. Blend Tanks, Temp. GBT Building, Digester Building, Polymer and MCC 12 Building, etc. (Aug-Sep 2016)
Demolish Feeder from Switchgear DH to Blend Tanks, MCC 12, and Old PS 15

Relocate GBT 6

Start Operation of New Blend Tank (Jul 2016)

Phase III GMP 1 Const. Complete – July 2016

PS 10 and PS 11 Modifications

Demolish Feeder from Switchgear DH to Blend Tanks, MCC 12, and Old PS 15

8/1/2015

Jul-Sep 2016
Questions?