The Art of Mixing, Anaerobic Digesters

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Aims

- Highlight the importance of getting digester mixing right

- Provide an overview of the current state of the art in digester mixing
Contents

➢ Importance of digester mixing
➢ Mixing objectives and design criteria
➢ Measuring and modelling mixing performance
➢ Digester mixing state of the art
➢ Digester and Sludge Mixing Software
Background

- Increasing number of digesters, mixing and holding tanks are in use
- Wide range of mixer types/sizes
- Few mixing criteria established or applied
- Reliance on mixer suppliers, no independent design information
- No link between rheology and mixer sizing
- Variable “success” of installed mixers
Industry Needs

Why is mixing so increasingly important?

- Thicker feed sludges to improve throughput, leading to thicker digestate
- Smooth out variability in feed physical properties
- Maximise gas production
- Maintain uniform digester temperature
- Avoid built-up deposits on digester floor
- Dilute inhibitory substances entering digester
- Avoid short circuiting to maximise pathogen kill
Mixing Objectives

What should the mixer achieve?

- Blending feed sludge into the bulk
- Generate the desired flow pattern
- Minimise dead or stagnant zones
- Avoid solids accumulation
- Scum drawdown
- Enable tank emptying
Defining Mixing Criteria

- Feed Slurry Blending
  - Blend Time: time taken to achieve a predetermined degree of concentration homogeneity
  - 90% blend time: the time taken for concentration fluctuation to be within +/- 10% of the mean concentration
  - Typically, 90% or 95% blend times of 1 to 2 hours are specified for digesters

- Active volume
  - The ‘non stagnant’ volume
  - Typically, 90% or 95% specified

- Extend of short circuiting
Modelling Performance

- Published Design Information
  - Digester mixer design
  - Chemical process mixer design

- Physical Modelling
  - Clear simulants for slurry & feed
  - Velocity and blend time measurements
  - Wash out curves

- Computational Fluid Dynamics
  - Flow patterns, velocities and blending
Digester Mixer Design Consideration

- Digester shape (base & aspect ratio)
- Feed & digestate rheology
- Location of inlets & outlets
- Digester feed rate & cycle
- Digester flow pattern & residence time
- Mixer type and size
State of the Art

➤ Feed location
State of the Art

- Impellers
State of the Art

- Jets
State of the Art

- Unconfined Gas
  - Continuous or sequential gas addition through the nozzles
    - No difference for low viscosity digestate
    - Sequential superior for high viscosity digestate
WWM Scope for Digester Mixing

- CR8239 Sludge Tank & Digester Mixing Research Report
- CR8237 Digester & Sludge Tank Mixing Design Guide
  - Mixer design, rating, and selection guide
  - Linked to performance criteria
  - Sludge rheology dependent
  - Based on physical modelling and CFD
Digester & Sludge Tank Mixing Software

Aims:

► Enable easier and practical application of the paper design guidelines
► Allow range of mixing scenarios based on combinations of different tank geometries, sludge properties, mixer type
► Allow rating of digester mixing performance
Digester & Sludge Tank Mixer Software

- Excel based software
  - Non newtonian fluids (Power Law and Herschel Bulkley)
  - Transitional and turbulent regimes
  - Jet and submersible mixers
  - Impeller mixers (focus on axial impellers)
  - Unconfined gas mixers
- Two primary criteria
  - Blend time
  - Active or cavern volume calculations
Digester & Sludge Tank Mixer Software
Digester & Sludge Tank Mixer Software

Tank Geometry

Jet Mixer

Gas Mixer

Mixing Requirements

Design Recommendations

Warnings

Number of warnings:

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# Digester & Sludge Tank Mixer Software

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Thank you

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