CFD for Wastewater Sedimentation Examples

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Presentation Outline

• CFD Modeling History
• CFD Approaches to Sedimentation
• Case Histories:
  • EDI Evaluation Case History
  • Feedwell and Effluent Zone Case History
Typical CFD Discretization Approaches

- Finite difference (FD) was the first approach to be used.
- Finite element (FE) has been used in recent past.
- Control volume (FV) approach used by current commercial codes.
Typical CFD Pressure Elimination Approaches

- Vorticity / stream function (V/SF) was the first approach and is still used.
- Semi-Implicit Method for Pressure-Linked Equations (SIMPLE) used by most current commercial codes.
Typical CFD Turbulence Modeling Approaches

- Constant eddy viscosity or field-fit eddy viscosity used in early work.
- Mixing length (ML) theory still used.
- Commercial codes now typically use k-epsilon.
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### Significant Milestones in the Early History of Sedimentation Modeling

<table>
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<tr>
<th>Researcher</th>
<th>Date</th>
<th>2D/3D</th>
<th>Approach</th>
<th>Discretization</th>
<th>Turbulence</th>
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<tr>
<td>Larsen</td>
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<td>V/SF</td>
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<td>Vitasovic et al.</td>
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<td>De Clercq</td>
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<td>McCorquodale &amp; Griborio</td>
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<td>2D</td>
<td>V/SF</td>
<td>FD/FV</td>
<td>ML</td>
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Typical CFD Settling Model Approaches

- Vesilind Equation
  \[ V_s = V_o e^{-kX} \]

- Takac’s equation
  \[ V_s = V_o \left[ e^{-k_1 (X - X_{\text{min}})} - e^{-k_2 (X - X_{\text{min}})} \right] \]

- McCorquodale’s five-component model
Modeling Flocculation (McCorquodale et al. 2004)

- Differential settling flocculation:

\[
\frac{dC_1}{dt} = - \frac{3}{2} k_{ds} \frac{C_1 C_2}{\rho_1 \rho_2} \left( 1 + 2 \frac{d_1}{d_2} \right)^2 \frac{C_1}{d_2} (V_{S2} - V_{S1})
\]

- Shear-induced flocculation

\[
\frac{dn}{dt} = K_B \ast X \ast G^m - K_A \ast X \ast n \ast G
\]

\[\text{Floc Breakup} \quad \text{Floc Aggregation}\]
Case Study 1: Radial Flow Clarifier

- 3D Fluent CFD
- 1,100,000 hexahedral cells
- K-epsilon turbulence model
- User defined functions (UDF) to implement
  - Solids settling and transport (Vesilind Eqn.)
  - Density coupling
Solids Profile Comparison to Simulation

Model Prediction

Field Test Data

Comparison of Field Test Data to Model
8 mgd 2200 mg/L MLSS 80 mL/g Pitman SVI
Existing Configuration Performance
Alternative EDI Configurations
Alternative EDI Velocity Vectors

- Target Baffle
- Tangential EDI
- Concentric Tub EDI
- Satted EDI
  10 mgd Velocity Vectors at 17.4 feet Height
Alternative EDI Velocity Plans
Alternative EDI Velocity Profiles
Alternative EDI Velocity Profiles
Alternative EDI Solids Profiles