Dynamic Process Modeling for Managing Energy Efficiency

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Outline

• Battle Creek WWTP
  – Energy Evaluation
  – Control Strategy

• Stickney WRP
  – Energy Evaluation
  – Blower Operation
## Acknowledgements

**Battle Creek WWTP**
- Rich Beardslee
- Chris Dopp
- Carl Fedders
- Kurt Tribbett
- Perry Hart
- Marvin Krause
- Bryan Crawford
- Chris Pratt

**MWRDGC**
- M&R
- M&O
- inCTRL Solutions, Inc.
- Carol Naughton & Associates
- Environmental Design International, Inc.
Battle Creek Background
Background: Battle Creek

- Design capacity 27 mgd
- Currently operating at 9 mgd
- Significant loadings from food processors and paper
  - Influent BOD
    - 580 mg/L (2013-2014)
    - 650 mg/L (2015)
Background: Battle Creek
Background: Battle Creek

Process Type: Single-Stage Activated Sludge with Nitrification
• Project Drivers
  – Energy conservation
  – Aged facilities: Blowers cannot be repaired
  – Aged facilities: Outdated aeration control
  – Process Improvements: Nutrient deficiency issues
  – Chemical Savings: Phosphorus control
Battle Creek Evaluation
Dynamic Evaluation

Airflow (scfm)

Airflow Required
Airflow Supplied
## Blowers

<table>
<thead>
<tr>
<th>Blower Information</th>
<th>Centrifugal</th>
<th>PD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. of Blowers</strong></td>
<td>3</td>
<td>3*</td>
</tr>
<tr>
<td><strong>Firm No. of Blowers</strong></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td><strong>Motor Size (Hp)</strong></td>
<td>1000</td>
<td>450</td>
</tr>
<tr>
<td><strong>Manufacturer</strong></td>
<td>Hoffman</td>
<td>Sutorbilt</td>
</tr>
<tr>
<td><strong>Voltage (V)</strong></td>
<td>4160</td>
<td>460</td>
</tr>
<tr>
<td><strong>Turndown Method</strong></td>
<td>Inlet Throttling</td>
<td>None</td>
</tr>
<tr>
<td><strong>Maximum Flow (scfm)</strong></td>
<td>21,000</td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Minimum Flow (scfm)</strong></td>
<td>13,000</td>
<td>7,000</td>
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</table>

<table>
<thead>
<tr>
<th>Blower Information</th>
<th>New Turbo</th>
<th>Existing Centrifugal</th>
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<tbody>
<tr>
<td><strong>No. of Blowers</strong></td>
<td>4</td>
<td>2</td>
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<tr>
<td><strong>Firm Capacity</strong></td>
<td>4</td>
<td>1</td>
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<tr>
<td><strong>Motor Size (Hp)</strong></td>
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<td>1000</td>
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<tr>
<td><strong>Voltage (V)</strong></td>
<td>480</td>
<td>4160</td>
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<tr>
<td><strong>Turndown Method</strong></td>
<td>VFD</td>
<td>Inlet Throttling</td>
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<tr>
<td><strong>Maximum Flow (scfm)</strong></td>
<td>7,500</td>
<td>21,000</td>
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<tr>
<td><strong>Minimum Flow (scfm)</strong></td>
<td>3,500</td>
<td>13,000</td>
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</tbody>
</table>
Operating Range

- Remaining centrifugal blower capacity
- New turbo blower capacity

Airflow (scfm) vs. Percent of Time Equal or Less Than:
- Average Daily
- Peak Instantaneous
Power Comparison

57% Reduction in Energy
Controlling Rate of Nitrification with Ammonia-Based DO Control

Conceptual Example

NH₃ (mg/L) vs Time (Beginning of Tank to End of Tank)

- NH₃ Control
- DO Control
Ammonia-Based DO Control

Controlling Rate of Nitrification Based on DO Concentration

Significant impact on growth rate over potential range of DO concentrations
Ammonia Control Loop v2

DO Control with Air Header Pressure Based Blower Control

DO Control Loop

Ammonia Control Loop

Ammonia Setpoint(s) automatically adjusted to maintain ammonia concentration setpoint

Operator Input: Ammonia Setpoint

Pass 1

DO

Ammonia

Pass 2

Control Clamp: Min/Max Airflow

FIT

Pressure Control Loop

To Other Tanks/Passes

Blowers

PIT

Operator Input: Ammonia Setpoint
Ammonia-Based DO Control

Controlling Rate of Nitrification with Ammonia-Based DO Control

- Slowly Decrease DO Setpoint Until Ammonia Reading is in Desired Range
- Conceptual Example
- Goal Range For This Example
Stickney WRP Background
Average Primary Effluent

- Flow: 787 mgd
- BOD$_5$: 155 mg/L
- NH3-N: 17 mg/L
- TP: 7.67 mg/L

Average Secondary Effluent

- BOD$_5$: 7.74 mg/L
- NH3-N: 0.57 mg/L
- TP: 1.4 mg/L
- TSS: 5 mg/L
Stickney Evaluation
Aeration System Model

- Flow Split:
  - In1
  - Out1
  - Out2
  - Out3
  - Out4

- Aeration Batteries:
  - In1
  - Out1
  - Out2

- Influent

- Effluent1
- Effluent2
- Effluent3

- Diffuser submergence: 0
- Temperature: 4.54°
- Excel

Air_Required: 2.403e+04
Air Demand Distributions

Airflow (scfm)

- Total Airflow Data
- DO Control
- Ammonia Control
## Aeration Blowers

<table>
<thead>
<tr>
<th>Blower Number</th>
<th>Type</th>
<th>Min (psig)</th>
<th>Max (psig)</th>
<th>Min (scfm)</th>
<th>Max (scfm)</th>
<th>Current Min (scfm)</th>
<th>Current Max (scfm)</th>
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<tbody>
<tr>
<td>4 - 7</td>
<td>Axial Flow</td>
<td>7.1</td>
<td>8.1</td>
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<td>210,000</td>
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<td>39,000</td>
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<td>-</td>
<td>75,000</td>
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<tr>
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<td>Centrifugal</td>
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<td>8.1</td>
<td>92,500</td>
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<td>-</td>
<td>186,000</td>
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Blower Operating Ranges