Evaluation Of Aeration Control

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Outline

- Introduction
- Aeration control – Why is it important?
- Control system levels and strategies
- South Plant testing and modeling

Why is Aeration Control Important?

- High operating cost
- Crucial to the process
Typical Energy Consumption Profile

Aeration Energy Cost
- 20 mgd plant
- Annual energy cost: $750,000

Aeration System Energy Consumption
- Aeration system: 50-70%
- All other systems: 30-50%

Factors That Affect Aeration Power Cost
- Water depth
- Type of diffuser
- Type of blower
- Friction losses
- Degree of control
Aeration Control System Levels

- Manual
- Auto control of common air header
- Auto control of each aeration basin
- Auto control of each aeration zone
**General Summary and Conclusions**

- Aeration systems are the biggest consumers of energy in a WWTP
- Energy consumption of aeration systems can be optimized with proper level of control

**South Plant Testing and Modeling**

- Within a single basin, where is the best place to control?
  - Performed dye test to determine hydraulic character of the aeration tank
  - Used commercial simulation program to calibrate air flows to demand distribution
  - Used customized model to test impact of control at different locations

**Tank Schematic**

**Dye Test Results : End of Pass 4**
Dye Test Results: End of Pass 2

COMPARISON OF EXPERIMENTAL DATA AND TANKS IN SERIES MODEL PREDICTIONS

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>C/C</th>
<th>Experimental Data</th>
<th>Best Fit (N=18)</th>
<th>N=10</th>
<th>N=30</th>
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<td>0.0</td>
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Schematic: 56-celled BioWin™ Model

Calibration: 56-celled BioWin™ Model

Biowin™ Schematic – 12-celled System
Control Modeling: DO Distribution

- Single Point Control

0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0

Each Zone

Probe 1  Probe 3  Probe 5  Probe 7  Probe 9  Probe 11  Probe 12

Control Modeling: Air Flows with Two Points of Control

0 20,000 40,000 60,000 80,000 100,000 120,000 140,000

Total Air Flow (cfm)

Probe 6 and 12
Probe 6 and 10
Probe 5 and 12
Probe 5 and 10
Probe 4 and 12
Probe 4 and 10
Probe 3 and 12
Probe 3 and 10
Probe 1 and 12

Control Modeling: DO with Two Points of Control

- Even though hydraulics indicate a 56-celled system, a 12-celled model is adequate for modeling control
- Optimal control is two point control
  - Probe 6 and 12
  - Probes 5 and 10

Conclusions South Plant Modeling
Acknowledgements

- King County Department of Natural Resources and Parks
- Carollo Engineers

Most Common Control Strategies

- Buffered pressure control
- Most open valve control
- Incremental control

Buffered Pressure Control

- Modify aeration air control valves to deliver setpoint DO
- This changes the aeration header pressure
- Modify blower output to keep a constant header pressure setpoint

Questions?
**Most Open Valve Control**

- Designed to minimize pressure losses
- Adjust control valves to maintain DO setpoints in the tanks
- Poll the valves and adjust blower capacity to keep at least one valve in the desired open condition (80-95% open)

**Incremental Control**

- Abandon PI and/or pressure control
- Vary airflow in increments based on step changes in DO

**Effect of Water Depth**

- Transfer efficiency goes up with increased depth
- But so does blower head
- Net wire to water difference usually small

**Factors that Affect Diffuser Transfer Efficiency**

- Type of diffuser
  - Coarse bubble
    - Tray or Bubble Cap
  - Fine bubble
    - Tube
    - Disc
    - Panels
- Air rate per diffuser
- Area Loading Rate
- MLSS Concentration
Aeration Air System

- Air Supply System
- Air Distribution System

Air Supply System

- Filters
- Silencers
- Piping and Valves
- Blowers

Flow/Pressure Table

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<tr>
<th>CONDITION</th>
<th>FLOW</th>
<th>PRESSURE</th>
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<tr>
<td>Maximum</td>
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</table>

Flow/Pressure Graph
Blower Types

- Positive Displacement (PD)
- Centrifugal
  - Multi-stage
  - Single-stage

Multi-Stage Centrifugal

Single-Stage Centrifugal

Positive Displacement
DO Profile

Aeration Air Demand Variation

- Minimum: 50-70% of Average
- Maximum: 140-160% of Average

Air Distribution Control System

- DO Probes
- Air Flow Meters
- Air Flow Control Valves
- Controller

Potential Problems with MOV Systems

- Improperly sized valves (too big)
- Pressure regulation time scale must be slower than DO change
- Integrator windup ($K_i \int e \, dt$)
- Process dynamics
Potential Solutions to MOV Problems

- Properly size control valves
- Dampen control loops
- Tracking
  - Keep track of integral error for all regulators
- Continuous tuning strategies
  - Gain scheduling
  - Self tuning
  - Exact linearization

Carollo Experience with MOV

- Problems at Orange County
  - Hunting of valves and blower
  - Converted back to pressure control
- Working well at Clark County
  - Only two basins
  - Controlling air flow to zones rather than DO