Advances in Aeration Control
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Advances in Aeration Control
• Importance of Aeration Control
• Advances in Aerators
  • Diffused
  • Mechanical
• New Blower Technologies
  • Turbo
  • Screw Blowers
• Advances in VFDs
• Improved Instrumentation & Control Strategies
  • DO Control Techniques
  • Feedforward Control
Factors Driving Advances in Aeration Control

- More Demanding Permit Requirements
- More Complicated Processes
- Higher Energy Costs
- Increased Global Technology Transfer
- Improved Instrumentation Hardware

Improved Control Means More Stable Processes

- Process Performance Comes First!
- Adapting Automatically to Upsets and Changes Can Improve Performance
- Control Strategies Must Integrate Process Equipment Characteristics
- Most Municipal WWTPs Operate at 1/3 of Design Capacity

CONSIDER TAKING TANKS OUT OF SERVICE
Energy Is A significant Concern, and Can Be Used To Justify Systems

Aeration is the Most Significant Energy Use in a WWTP

Most Utilities Offer $ Incentives for Reducing Energy Use

Energy Consumption ≠ Energy Cost

Rates vary with:
- Time of Day
  - On-peak, Off-Peak
- Day of Week
- Size of Costumer
- Demand (kW) and Consumption (kWh)

The First Goal of an ECM (Energy Conservation Measure) is to Reduce Cost While Maintaining or Improving Process Performance
Mechanical Aerators

Variable Speed or On/Off Mechanical Aerators

Diffused Aeration

Coarse Bubble

Changing to Fine Pore Diffusers Should Always Be Examined!
New Aeration Technologies:

- Mixing and Aeration Combined
- Actually Re-invention of Older Technology
- Allows Separate Control of Oxygen Transfer and Mixing Energy
- New Diffuser Geometries and Materials
  - Fouling Resistance
  - Improved OTE

Diffused Aeration Energy

- Proportional to Submergence
  - Deeper is Better
  - Also Requires Higher Blower Power
- Proportional to Air Flow per Diffuser
  - Flux Rate (1 to 10 SCFM/ft² Typical)
  - Lower is better
- Proportional to Actual DO Concentration
  - Lower is Better
  - DO Control is Significant
  - Most Plants Are Too Conservative In DO Setpoint
**Diffused Aeration**

Excess DO means significantly more aeration power.

![Blower Power Ratio (Compared to 2.0 ppm DO)](image)

\[
\frac{Q_{\text{actual}}}{Q_{2.0}} = \frac{C_{\text{sat}}^* - 2.0}{C_{\text{sat}}^* - C_{\text{actual}}}
\]

Based on 500' ASL, 55 °F, 9.9 ppm \( C_{\text{sat}} \)

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**Impact on Control Systems**

- **Lower Air Flow Rates**
  - Reduce Valve Sizes
  - Re-Scale or Replace Flow Transmitters
  - Mixing Limits
- **Impact on Blowers**
  - Turndown May Become an Issue
  - Verify Pressure Capacity (More Submergence)
- **DO Control**
  - Maximizes Savings Opportunity
  - Over-Aeration More Common
Aeration Blowers and Energy

Efficiency Varies with Blower Type
Range is 60% to 80%

Blower Considerations

- Efficiency
  - Across Actual Load Spectrum
- Control
  - Constant Pressure or Flow Based
  - Control and Protection Should Be Integrated
- Turndown
  - Often More Important Than Efficiency
  - Turndown Limits Must Be Included In Control Strategy
Example Turbo Blower Characteristics

Example Screw Blower Characteristics

Typical Screw Blower Performance at Constant Speed

55 °F, 14.4 psig
Blower Control Considerations

- Blower Control Usually Included In Packages
  - Screw Blowers
    - Typically More Turndown
    - Control Simpler
  - Turbo Blowers
    - Often More Efficient and Lower Cost (CHANGING)
    - Turndown Limits Must Be Included In Control Strategy – Surge Is a Concern

VFD Applications Have Changed

- VFDs Are More Reliable And Less Costly
- Many Utilities Offer “Automatic” VFD Incentives
  - Can Be Applied to ALL Types of Blowers
    - Proper Selection and Engineering is Required
  - Medium Voltage (> 600 Volts) Now Cost Effective
    - Increased Competition, Lower Prices
    - Typically Greater Than 750 hp
Payback on Medium Voltage Drives Can Be Good

![Cumulative Operating Cost Graph]

DO Control Can Be Very Cost Effective

• Will **Save 25% Or More** Compared to Manual
  • Matches Air Supply To Demand
  • **Usually Improves Process Stability**
  • DO Is An Indirect Indicator of Process Performance
• Low Capital Cost May Make Payback Shorter Than Other Changes
• Control Complexity Should Be Matched to System
  • Total Blower Air Flow Only
  • Individual Basin Flow Control
  • Separate Grid DO and Flow Control Within Basins
• New Strategies Improve Efficiency
  • Most-Open-Valve
  • Direct Flow Control Eliminates Pressure Control
Most-Open-Valve Control

- MOST-Open-Valve (MOV) Control is NOT Necessary for DO Control or Blower Control

- Technique for Minimizing System Pressure by Keeping at Least One Basin Valve at Max Position at All Times

- Older Systems Work By Adjusting Pressure Setpoint

- Newer Strategies Work Directly With Flow Control

Pressure Control

- If Constant Pressure Is Maintained Changes in One Valve Won’t Affect Other Basin’s Air Flows

- If Pressure Setpoint is Too High Power Is Wasted
Direct Flow Control

- Is Simpler and More Stable
- Typically Reduces Blower Power 5% to 10%

New Analytic Instruments for Control

- Optical DO Probes Replacing Membrane Types
- Multi-Channel and Remote Transmitters
- New Nutrient Analysis Instruments
  - Chiefly for Nutrients – Nitrification/Denitrification
  - Many Still Maintenance Intensive
- Most Ammonia Control Strategies Used In Conjunction with DO Control
- New Feedforward Controls Based on Measuring Process Demand
Offgas Based Feed Forward Control

- Determines Air Demand By Measuring OUR and OTE
- More Stable and Precise

Use Simple Payback To Calculate Cost Effectiveness

- Process Requirements Come First!
- Use Present Worth for Longer Time Periods
- Implementation for Energy Conservation Should Be Justified By Best Payback

\[
\text{Payback}, \text{ years} = \left( \frac{\text{Equipment Cost}}{\text{Annual Savings}} \right)
\]
Aeration and Energy

Over Life of Equipment:
Energy Cost is more Significant than Equipment, Installation, or Maintenance Costs

Figure 4. Life Cycle Cost comparison (overall cost vs. months of operation).

Questions?