Treatment Facility Performance Optimization Using Automatic Control and Online Monitoring

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Process Engineer
Levels of Control

- Manual based on manual samplings
- Manual based on online measurements
- Automatic with online measurements
  - Single-variable feedback control
  - Multi-variable intelligent control
Why Instrumentation & Automation?

- Eliminates judgment call
- Provides instantaneous decision based on real-time data
- Provides operational cost and labor hour savings
- Avoids poor treatment and effluent violations
- Provides stable process
Activated Sludge Process Control

Influent → Aeration tank → Mixed liquor → Clarifier → Effluent

- Return Activated Sludge (RAS)
- Chemical Feed
- Air

Waste Activated Sludge (WAS)
What is Solids Retention Time (SRT)?

Solids Retention Time = average duration of time an organism spends in the system

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SRT = \frac{\text{Basin Mass}}{\text{Mass wasted per day}} = \frac{\text{Basin volume} (m^3) \cdot \text{MLSS (mg/l)}}{\text{WAS Q} (m^3/\text{day}) \cdot \text{WAS TSS (mg/l)}} = \frac{\text{kg}}{\text{kg/day}} = \text{days}
\]
Black River Falls (BRF) WWTP

Effluent Discharge Permit

- $\text{BOD}_5 = 30 \text{ mg/l}$
- $\text{TSS} = 30 \text{ mg/l}$
- $\text{TP} = 1.0 \text{ mg/l}$

Design/Average Flow

- $0.86/0.60 \text{ MGD}$
BRF WWTP Process
Problem Statement

Process Aeration

- Manual Aeration Control
  - Blower speed was adjusted based on observed DO concentration.
  - Limited control

DO: Dissolved Oxygen
Process MLSS/SRT

- Manual Sludge wasting based on time
  - Amount of sludge wasted was unknown
  - What happens if valve failed to close
  - What happens if valve is not closed on time by operators
  - Limited success in maintaining desired SRT/MLSS conc.

MLSS: Mixed Liquor Suspended Solids
SRT: Solids Retention Time (Sludge Age)
Chemical P Removal Process

- Manual Chemical addition based on effluent TP concentration
  - Concentration of reactive ortho-phosphate is unknown
  - Potential waste of chemical(s)
  - Unstable basin pH
Optimization Objectives

Test following **automatic control algorithms** against **manual control** to examine process stability and treatment efficiency optimization.

- Automated Aeration Control (DO control)
- Operator Desired Solid Retention Time (SRT) Control
- Process Optimized SRT (Smart SRT) Control
- Operator Desired MLSS Control
- Automated Chemical Dosing Control

DO: Dissolved Oxygen  
MLSS: Mixed Liquor Suspended Solids  
SRT: Solids Retention Time (Sludge Age)
Monitoring & Control Improvements

\[
SRT = \frac{\text{Basin Mass}}{\text{Mass wasted per day}} = \frac{\text{Basin volume} (m^3) \cdot MLSS (mg/l)}{\text{WAS } Q (m^3/day) \cdot \text{WAS TSS} (mg/l)} = \frac{\text{kg}}{\text{kg/day}} = \text{days}
\]
Monitoring System Improvements
Control System Improvements
Process Aeration (DO) Control

DO control reduced energy consumption on average 10-15%
Operator Desired MLSS Control

**Without OSCAR™ Control**
- MLSS concentration varies from 1900 to 2600 mg/l
- No control during weekend or holidays

**With OSCAR™ Control**
- MLSS was maintained close to the setpoint (2100 mg/l)
- Stable MLSS concentration over long operational period
Operator Desired SRT Control

Without OSCAR™ Control

- SRT varies of 8 to 22 days
- Under/Over treatment
- Waste of energy
- Tedious manual wasting

With OSCAR™ Control

- Automatic Wasting
- Stable operator desired SRT
- Optimized treatment
Process Optimized SRT (Smart SRT) Control

Desired Treatment

- Effluent ammonia concentration less than 1.0 mg/l

Without OSCAR™ Control

- Manual wasting

With OSCAR™ Control

- Desired SRT was calculated based on process parameters
- Maintained SRT by automatic wasting adjustment
- Effluent ammonia conc. was always less than 1.0 mg/l
- Optimized process operation
Results – Energy consumption

Significant difference in energy consumption from running at a higher SRT:

- **12%** higher energy consumption
- **9%** lower aeration efficiency

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Ása Henriksson and Alexis de Kerchove. ‘Smart Biomass Control Saves Energy While Maintaining Treatment Objectives.’ WEF Water and Energy 2015, Washington, D.C.
Without OSCAR™ Control

- Manual dosing of FeCl₃ for P removal
- Caustic addition (50% of FeCl₃ volume) to recover alkalinity

With OSCAR™ Control

- Controlled FeCl₃ dosing for P removal
- Nearly elimination of caustic dosing
- 45% FeCl₃ and 100% caustic savings
- Consistent effluent TP (<1.0 mg/L)
- 24/7 control
Conclusions

**Process Aeration**
- Process Stability and 10-15% energy savings

**Process MLSS/SRT**
- Flexible and Stable operation 24/7
- O&M hours savings
- Energy savings
- Visibility into dynamic process parameters such as MLSS, SRT, and mass wasted

**Chemical P Removal Process**
- Consistent effluent TP concentration (<1.0 mg/L)
- Chemical cost savings

**Consistent effluent BOD, TSS and NH₄ concentration**
Aeration Control Flexibility

- Dissolved oxygen control
  - Optimize air supply

- Air flow control
  - Stabilize process

- Pressure control
  - Minimize pressure loss

DO control
SIMS Control Flexibility

Set preferred run time or volume for each wasting event

Control to an operator selected MLSS

Control to an operator selected SRT

Control to an optimized SRT calculated based on real-time process parameters
Trouble-free Control

Careful and stable adjustments ensure a healthy biomass

- Avoids fast process changes
- Maintains a healthy SRT also in MLSS mode

Trouble-free control

- **We know our probes:**
  - Automatic detection of probe cleaning or calibration needs
  - During probe maintenance, SIMS switch to a separate control mode to avoid control using invalid data

- **We know the process:**
  - Automatic detection of process upsets or unhealthy biomass
  - As issues are detected, SIMS switch to a safe mode and an alarm is sent to the operator
Implementation of Online Monitoring and OSCAR™ Control

Automatic vs. Manual control

‘Historically, we ran our waste activated sludge pump manually for a certain period of time per day. We love the way the OSCAR™ SIMS control system is automatically controlling wasting based on our need, maintaining stable operation and providing superior effluent quality.’

‘We love the way the OSCAR™ aeration control system is automatically controlling blower speed and operation, and maintaining stable DO concentration that we never achieved during manual operation. Currently, we do not need to worry about blower operation during work days, weekends or long weekends.’

Rick and Bill
Black River Falls WWTP Operators
Black River Falls, WI
Why Xylem?

**Expertise**
- Process Expertise
  - ICEAS
  - BioLoop
  - Conventional ASP

**Application Expertise**
- Aeration
- Mixing
- Pumping

**World-class products**
- Sanitare
- Flygt
- WTW
- YSI

**Advanced Process Control**
- Sustainable, optimized process
- Energy efficiency
- Operational excellence

**TotalCare services**
Questions?

- **Web:**  [www.xylem.com/treatment/us](http://www.xylem.com/treatment/us)
- **YouTube:**  [www.youtube.com/user/SanitaireUS](http://www.youtube.com/user/SanitaireUS)
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