Case study

Pushed to the limit: Saving energy and improving treatment at high loads

Results from Hammarby Sjöstadsverk, Sweden

Wastewater treatment plants (WWTP) are facing many challenges. The treatment requirement for nitrogen and phosphorus are progressively becoming stricter. At the same time, plants are required to reduce the consumption of energy and chemicals and are often challenged with limited time and staff. This sums up to an impossible equation, as an increased treatment requirement typically results in higher energy and chemical demand.

To meet these challenges, an advanced process control system was implemeneted in a highly loaded Sequencing Batch Reactor (SBR) pilot plant in Hammarby Sjöstadsverk, Sweden. It was found that by controlling the process in a smarter way and optimizing for daily and weekly load variations, the solution resulted in significant reduction in required aeration time and energy without risking permit violation.

Plant data

The study was conducted at a pilot plant with a continuous feed ICEAS advanced SBR situated at Hammarby Sjöstadsverk (Nacka, Sweden). During the study, the influent and effluent streams to the SBR were monitored with 24-hour composite samples analyzed for organic material, nutrients and suspended solids. Online sensors of ammonia (NH_4), nitrate (NO_3), total suspended solid (TSS), orthophosphate (PO_4) and dissolved oxygen (DO) concentration were placed in the SBR basin. In addition, the solids retention time (SRT) and mixed liquor suspended solids (MLSS) of the process, as well as the energy consumed by the blowers, was monitored.

Influent load

The plant was designed for a minimum temperature of 10°C while the operating temperature during the study was 16°C. To compensate for this the SBR was fed a load 2.5 times greater than the original design, resulting in the process operating at near maximum capacity.

TEST PLANT: Hammarby Sjöstadsverk, Sweden
PROCESS: Sanitaire ICEAS advanced SBR
DESIGN FLOW: 4500 GPD / 17 m^3/day
TEST: Dec 2016 – Jan 2017

INFLUENT LOAD

		Design	Actual
Flow	Gpd	4500	6600
	m^3/day	*17*	*25*
BOD	kg/day	3.3	8.8
TN	kg/day	0.8	1.5
Temp	C	10	16

DESIGN EFFLUENT PERMITS

NH4	Mg/l	1
BOD	Mg/l	10

Nutrient removal control system

The SBR was upgraded with an OSCAR process performance optimizer control system with the NURO controller. With a combination of online sensor measurements and process knowledge, this nutrient controller continuously adapts the process conditions to the current requirement to meet an operator selected desired effluent ammonia concentration while minimizing aeration. By continuously adjusting to the current conditions, the controller avoided energy waste from over-aeration while providing additional time for anoxic and anaerobic treatment, enabling improved denitrification and biological phoshporus removal.

Result: Energy savings

When operating with a load close to maximum treatment capacity, there is typically little room to save energy without risking permit violation. The high load meant that most of the treatment cycles required aeration as designed to meet permit. However, by automatically adjusting for the daily and weekly load variation and detecting lower loaded cycles, the controller still reduced aeration time and saved energy while still meeting permit.

During the study, the process was on average aerated for 6.7 hours per day, 33% less than the designed 10 hours per day. Before the NURO controller was enabled, the plant was operated with the designed treatment cycle and DO control. Implementing the NURO controller reduced energy consumption from 23 to 20 kWh/day – a savings of 13%.

Result: Improved treatment

Besides saving energy, the advanced process controller enabled time for additional anoxic and anaerobic treatment. Despite receiving a load 2.5 times design, the plant not only fulfilled the effluent ammonia permit but also achieved significant denitrification, reaching an averge effluent NO_3 of 1.5 mg/l. Despite not being designed for biological phosphorus removal, the controller enabled biological phosphorus removal and reached an average effluent PO_4 of 0.8 mg/l and TP of 1.2 mg/l without any chemical added for phosphorus removal.

Conclusions

This study shows that optimization is possible even when operating at the treatment capacity limit. By upgrading an ICEAS system with an OSCAR system with NURO controller, the daily and weekly load variation were recognized in real-time, resulting in reduced aeration when possible. Energy consumption was reduced by 13% despite operating at the treatment capacity limit. In addition, optimizing aeration enabled additional nitrogen and phosphorus removal, reaching effluent NO3 of 1.5 mg/l and PO4 of 0.8 mg/l without chemical addition.

EFFLUENT CONCENTRATIONS WITH NURO CONTROLLER

BOD	mg/L	6.9
NH_4	mg/L	0.5
NO_3	mg/L	1.5
TN	mg/L	4.4
TO	mg/L	1.2
PO_4	mg/L	0.8

AERATION TIME AND BLOWER ENERGY CONSUMPTION

Aeration time per day		
Design	h/day	10
With NURO controller	h/day	6.7
Savings		33%
Blower energy consumption		
Before upgrade	kWh/day	23
With NURO controller	kWh/day	20
Savings		13%