ChemScan® Process Analyzer

Reprint

City of Orlando

The Iron Bridge Pilot Project

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Abstract

The pilot project described in the attached technical paper was performed using on-line analysis data obtained using a ChemScan Process Analyzer system.

Following this successful pilot study, the ChemScan system was expanded to accommodate additional sample points and parameters for process control at Iron Bridge. An additional ChemScan system was purchased for effluent analysis at this plant.

CITY OF ORLANDO

The Iron Bridge Pilot Project

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ABSTRACT

This paper will present concepts and data associated with the implementation of full-scale pilot studies performed at the City of Orlando's Iron Bridge Regional Water Reclamation Facility. The goal of the project is to determine the maximum capacity of the Bardenpho process trains while maintaining reliable, permit-quality plant effluent. By modifying and rerating the Bardenpho trains, staff intends to remove the facility's "ailing" Rotating Biological Contactor (RBC) train from service.

FACILITY OVERVIEW

The Iron Bridge facility is currently permitted for a treatment capacity of 40 mgd … 16 mgd in the aging RBC process, and 24 mgd in the Bardenpho process. Each of the four (4) Bardenpho process trains were initially designed to treat 6 mgd average daily flow (ADF). Each Bardenpho train is outfitted with two (2) 150 hp mechanical aerators recently upgraded with VFD units for speed control. The RBC facility equipment is reaching the end of its useful life, and its capacity must be replaced in some manner. A paper study was performed evaluating the cost of rehabilitating the mechanical RBC components; this cost was estimated to be in excess of $25 million dollars, exclusive of delivery and installation. The cost was considered excessive to rehabilitate a process that staff had grown to "hate," due to extensive PM requirements, difficult access to equipment, high humidity, odorous work areas and a constant battle with a never-ending snail population. The decision was made to evaluate the potential for re-rating the Bardenpho facilities.

STAFF FIRST PERFORMED A BENCH-SCALE PILOT STUDY

The mission of the bench-scale pilot plant project was to identify the microbiological activity, and settleability characteristics of the MLSS in the Bardenpho process when treating the Iron

Bridge influent wastewater including the Solids Handling sidestream flows. Staff was unsure of the potential impact on the Bardenpho process if solids handling sidestreams, which had been treated by the RBC trains, was combined with influent flow streams to the Bardenpho process. The main objective of the bench-scale pilot project was to study the mixed liquor quality to determine if the settling efficiency would be adversely influenced by a dominance of filamentous microorganisms (as strongly believed by the consulting engineer). The premise was that if the bench-scale pilot operated successfully, it would be reasonable to assume the full-scale Bardenpho plants will do the same.

The bench-scale pilot was a single tank unit with baffled clarifier. Air was supplied and dissolved with aeration equipment similar to that of a fish tank; diffuser stones and a small WisperJet air blower. Raw wastewater was pumped into the beginning of the aeration chamber, while Return Activated Sludge (RAS) was conveyed from the bottom of the clarifier to the aeration chamber from the drafting movement of the aeration pattern. Final effluent overflowed the surface weir of the clarifier and exited the bench-scale pilot by gravity.

Acceptable settleability of mixed liquor in the bench-scale pilot demonstrated that an activated sludge process could be operated while treating the influent flow plus solids handling sidestreams without developing a dominance of filamentous bacteria.

INITIAL CHALLENGE TO OVERCOME – SIDESTREAM TREATMENT

High levels of ammonia were returned in the Belt Filter Press filtrate processing anaerobically digested sludge. The recycled ammonia exerted a high oxygen demand on the Bardenpho process reducing capacity to treat the incoming waste and creating the need for supplemental aeration just to treat the original design flow of 6 mgd per train. To successfully decommission the RBC train, the filtrate had to be treated in the Bardenpho process.

To resolve the recycle ammonia problem, staff modified existing aerated sludge holding tanks to nitrify the filtrate flow. A portion of the biological waste activated sludge was directed to the holding tanks to establish a population of autotrophic bacteria for nitrification. Once established, the autotrophic bacteria in the holding tanks convert ammonia into nitrite and nitrate prior to entering the Bardenpho process.

This pilot process underwent various modifications to improve treatment, including the use of additional conditioning bays, and the addition of WAS from the Bardenpho process to create an activated sludge environment. The aerated conditioning tanks were used to convert the high strength NH_3 in the belt filter press (BFP) filtrate to NO_3. Instead of the high NH_3 placing a huge oxygen demand on the biological process, the NO_3 becomes a source of oxygen available for the biomass. The combined, treated sidestream was piped to the head of Phase II/III grit removal structure. The flow modification allows the treated sidestream to enter all of the Bardenpho trains depending on the valving arrangement.

This pilot study has been on-going for several years with a high degree of success. The operators have excelled in their performance to control this process, and to maintain acceptable quality in the Bardenpho process. After numerous samples and tests, which continue, staff has fine-tuned the sidestream process to convert ammonia in the BFP filtrate, as high as 1,000 ppm, to about 50 ppm (sometimes as low as 20 ppm) before being directed to the Bardenpho process.

As mentioned, the sidestream treatment process effectively creates a source of oxygen for the Bardenpho process, instead of exerting a demand for oxygen on the Bardenpho process. It has been proven that sidestream flows from the solids handling processes can be treated and directed to the Bardenpho process trains without sacrificing performance efficiency and effluent quality.

1ST FULL-SCALE BARDENPHO PILOT STUDY - AERATED ANOXIC PILOT

The first portion of the Bardenpho pilot project, performed over a 6-month period in 1999, involved installing diffused aeration in the originally designed 1st anoxic zone of the 5-stage Bardenpho train. The objective was to develop an aerated anoxic environment in which the autotrophic bacteria would oxidize ammonia to nitrate (nitrification), but limit the air supply to maintain the majority of the carbon ($CBOD_5$) available for denitrification. A multi-vane centrifugal blower, with a 200 hp motor, provided supplemental aeration during this phase of the project.

The purpose of the aerated anoxic pilot study was to identify the maximum capacity of each Bardenpho train in regard to nitrification and denitrification. Each train was originally designed for 6 mgd ADF (Average Daily Flow), with a design peak of 9 mgd; this equals a total Bardenpho capacity of 24 mgd ADF, with peak flows of 36 mgd. This study attempted to treat an average daily flow of 10 mgd in one train, with peak flows of 15 mgd. If successful, the Bardenpho process (four trains) would be capable of treating 40 mgd ADF, with a peak flow of 60 mgd. Possibly, additional process structures and equipment may be required to achieve the above-referenced flow rates, including new secondary clarifiers, RAS pumping, aeration blowers and chemical phosphorus polishing.

The pilot study was designed to aerate the 1st Anoxic tank to encourage the major portion of nitrification to take place in this zone. Also, the initial goal was to control the amount of air supplied to the Aerated Anoxic zone to maintain a deficit of oxygen (meaning all of the oxygen demand would not be satisfied). The anticipated result was to encourage a major portion of denitrification to take place in this aerated anoxic zone, allowing the Internal Recycle (IR) flow to be reduced, or totally shut off. The nitrification and denitrification that occurs in the aerated anoxic zone would greatly reduce the demand for oxygen in the Carrousel tank, which should allow for an increased volume of influent flow to be applied to the train. Also, as IR flow is reduced or shut off, the effective detention time within the 1st Anoxic and Carrousel tanks would be greatly increased.

RESULTS OF THE AERATED ANOXIC PILOT

After an exhaustive trial period, staff could not create a true aerated anoxic environment, where a large volume of air is supplied but a measurable D.O. content is not achieved. Maintaining a near zero D.O. in this aerated anoxic zone allowed high levels of ammonia to bleed through the tank. Increasing the air to improve nitrification, which reduced the ammonia values, resulted in a D.O. content of 3 to 4 ppm. The elevated D.O. level was considered detrimental because it encouraged aerobic heterotrophic bacteria to consume carbon while using free dissolved oxygen, instead of allowing facultative heterotrophic bacteria to use nitrates as their source of oxygen as they consumed carbon. Carbon is a valuable commodity, which becomes a limiting factor, when attempting to maximize biological denitrification efficiency.

2ND FULL-SCALE PILOT STUDY – SUPPLEMENTAL AERATION IN THE 1ST AEROBIC ZONE OF THE CARROUSEL

City staff relocated supplemental diffused aeration from the 1st anoxic zone to the 1st aerobic portion of the Carrousel aeration tank. In this study, traditional 1st anoxic (without aeration) was re-established. Supplemental aeration in the Carrousel tank was provided with the same multi-vane centrifugal blower, with an upgraded 250 hp motor. The 2nd pilot phase has remained in service since July of 1999. The goal of this work is to identify the maximum flow rate that can be successfully applied to a single train, optimum mixed liquor concentration for nutrient removal performance, optimum RAS rate for maximum secondary clarifier performance, optimum Internal Recycle rate for enhanced bioactivity and optimum SRT for overall process performance.

RESULTS OF THE SUPPLEMENTAL CARROUSEL AERATION PILOT

The results of this 2nd pilot study have been excellent. Additional aeration has allowed the flow treated to be increased from the original design of 6 mgd to 10 mgd. Nitrification has improved, and, with traditional 1st anoxic in place, denitrification efficiency was deemed acceptable. This mode of operation continues to be successfully treating an average of at least 10 mgd with daily peaks of about 17 mgd, while producing permit-quality effluent.

ON-LINE NITROGEN ANALYZER

Staff recognized early on they could not perform adequate manual sampling and nitrogen profile testing to identify the operational comparisons between the two supplemental aeration locations within the Bardenpho process. Sampling, analysis and control was developed utilizing an on-line nitrogen profile analyzer. The nitrogen profile analyzer receives MLSS samples drawn from the end of each pilot tank modified with supplemental aeration. The analyzer filters the samples through ultra-filtration modules and performs a UV spectrum analysis to identify the nitrite, nitrate and ammonia concentrations. Average sample analysis requires 4 to 5 minutes per batch sample. The on-line nitrogen analyzer, which trends and records process performance in real-time, allows the operators to make timely adjustments to the VFD on the mechanical aerators to optimize the nitrification and denitrification processes.

POLYMER ADDITION TO ENHANCE MLSS SETTLEABILITY

Due to the higher flow rates, and, possibly the high-rate biological activity rates, settleability of the mixed liquor has been adversely affected. Prior to the increased flow rate pilot testing, sludge blankets were typically 1 foot or less. Fluff layers above the sludge blanket hardly ever existed. During the 1st pilot phase, aeration of the 1st anoxic zone, fluff above the sludge blanket in the secondary clarifiers started to become a problem. At times, the fluff layer was drafted over the weirs. To reduce the fluff layer in the clarifiers, staff installed a polymer feed system, which supplied a solution of cationic polymer into the clarifier mixed liquor inlet splitter box. Within a few hours of activating the polymer feed system, clarifier sludge blanket fluff was greatly reduced.

During the 2nd pilot phase, supplemental aeration in the first aerobic zone of the Carrousel aeration tank, the fluff layer above the clarifier sludge blanket was significantly reduced. The polymer feed system was only used when MLSS settleability required chemical conditioning. Normal operation during the 2nd pilot phase did not require polymer addition to realize successful performance in the secondary clarifiers.

CONCLUSIONS

It is anticipated that the pilot studies will result in savings by modifying and rerating the existing Bardenpho trains as opposed to the more conventional method of building new tankage and support facilities. Supplemental air diffusers will be permanently installed in the Carrousel 1st aerobic zone, raw flow equalization tanks will be constructed and minor modifications will be made to clarifier flow splitting, RAS pumping and IR pumping, resulting in a facility rerating from 24 mgd to more than 40 mgd. As a conservative estimate at $3 per gallon for design and construction of Bardenpho process units, the anticipated savings will exceed $48 Million by attaining a 16 mgd increase in permitted treatment capacity.

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Table 1 : Bardenpho Process Equipment Summary

Process Area	Equipment/Component	#	Design Criteria
Bardenpho	Bardenpho Trains	4	6 mgd Avg Capacity Each
	Fermentation Tanks	4	606,000 Gallons per Tank 2,424,000 Total Gallons for All Fermentation Tanks
	Fermentation Mixers	8	Two Mixers per Tank Low Speed Turbine Mixers
	First Anoxic Tanks	4	606,000 Gallons per Tank 2,424,000 Total Gallons for All First Anoxic Tanks
	First Anoxic Mixers	8	Two Mixers per Tank Low Speed Turbine Mixers
	Carrousel Aeration Tanks	4	2,630,000 Gallons per Tank 10,520,000 Total Gallons for All Aeration Tanks
	Surface Mechanical Aerators	8	Two Aerators per Tank Two-Speed Motors 150 HP Motor
	Second Anoxic Tanks	4	890,000 Gallons per Tank 3,560,000 Total Gallons for All Second Anoxic Tanks
	Second Anoxic Mixers	8	Two Mixers per Tank Low Speed Turbine Mixers
	Reaeration Tanks	4	Coarse Bubble Diffused Aeration 150,000 Gallons per Tank 600,000 Total Gallons for All Reaeration Tanks
	IR Pump Stations	4	36 mgd Max per Train
	Total IR Pumps	12	Propeller Pumps Float Controlled 6 mgd Capacity Each Pump

Process Area	Equipment/Component	#	Design Criteria
Secondary Clarifiers	Secondary Clarifiers	8	100 Foot Diameter Tanks 3 mgd Avg Capacity Each Draft Tube RAS Removal
RAS/WAS Stations	RAS/WAS Wet Wells	2	Each Station Serves 4 Clarifiers Telescopic Valve for Each Clarifier in the RAS/WAS Wet Well
	RAS Pumps per Wet Well	3	Two-Speed Motors About 3,000 gpm Each Discharges to Head of Fermentation Tanks
	Total RAS Pumps	6	
	WAS Pumps per Wet Well	2	Submersible Pumps
	Total WAS Pumps	4	Constant Speed About 350 gpm Each

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Table 2 · Process Data Comparisons – One, 6 mgd Test Train

Test Train Process Item	Units	Aerated 1st Anoxic 6-month Results	Aerated Carrousel 8-month Results
Average Daily Flow	mgd	9.3	10.3
Peak Flow Rate	mgd	22.8	17.5
Based on Daily Composite Samples			
Influent $CBOD_5$	mg/L	219	250
Influent TSS	mg/L	211	263
Influent NH_3	mg/L	19.4	20.3
Influent TKN	mg/L	33.7	34.7
Influent TN	mg/L	35.6	35.4
Influent TP	mg/L	6.3	6.0
Aeration MLSS	mg/L	2450	2300
RAS TSS	mg/L	5700	4690
Sec Clar Eff NH_3	mg/L	1.4	1.1
Sec Clar Eff TN	mg/L	3.78	3.8
Sec Clar Eff TP	mg/L	0.83	0.76
Average ChemScan Data at Carrousel Weir			
NH_3	mg/L	3.52	3.5
NO_3	mg/L	1.76	2.7
NO_2	mg/L	1.91	0.5
Based on Process Flow Meters			
QRAS	mgd	6.1	8.9
R:Q Ratio	%	66	86
QWAS	Kgpd	306	385
Calculated Process SRT	Days	9.4	6.6
Based On Daily Composite Samples of Flow Entering the Effluent Filters			
$CBOD_5$	mg/L	3.2	2.6
TSS	mg/L	4.6	4.5

Test Train Process Item	Units	Aerated 1st Anoxic 6-month Results	Aerated Carrousel 8-month Results
NH_3	mg/L	0.8	0.7
NO_x	mg/L	0.7	0.3
TKN	mg/L	2.2	2.0
TN	mg/L	2.8	2.3
TP (after alum trim)	mg/L	0.5	0.4

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Table 3 · Process Performance Data Comparisons – 6 mgd vs. 10 mgd

Process Performance Item	Units	Design 6 mgd Train	Pilot 10 mgd Train
Detention Times (without RAS)			
Fermentation	hours	2.4	1.4
1st Anoxic	hours	2.4	1.4
Carrousel Aeration	hours	10.5	6.3
2nd Anoxic	hours	3.6	2.1
Re-aeration	minutes	36	22
Secondary Clarifiers (2 of 4)	hours	6.8	4.1
Detention Times (with RAS)			
Fermentation	hours	1.5	0.8
1st Anoxic	hours	1.5	0.8
Carrousel Aeration	hours	6.6	3.3
2nd Anoxic	hours	2.2	1.1
Re-aeration	minutes	22	11
Secondary Clarifiers (2 of 4)	hours	4.2	2.1
Secondary Clarification Loading Rates (2 of 4 Clarifiers)			
Surface Settling Rate	$gal/day/ft^2$	382	637
Weir Overflow Rate	gal/day/ft	9,554	15,924
Solids Loading Rate	$lbs/day/ft^2$	12.5	23.1