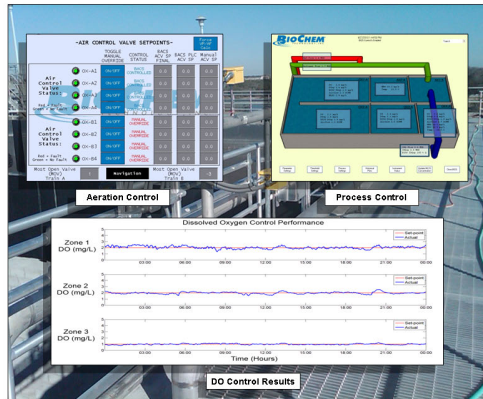


1. Abstract

In 2010 a 6 MGD Modified Ludzack-Ettinger (MLE) plant was successfully commissioned to operate under two advanced control systems with the goal of lowering effluent nitrogen concentrations while reducing energy consumption. Multiple startup obstacles in the form of operational complications, instrument and system failures have resulted in the development of a robust commissioning protocol capable of responding to and preventing the recurrence of many of the difficulties related with bringing a control system online. The methods compiled profile demonstrably successful approaches to time and projects management, programming, and process troubleshooting for commissioning control systems.



2. Background

As part of a scheduled upgrade, the use of an advanced aeration control system was deemed beneficial to the plant's overall stability and performance. The several week effort of integrating each plant control to a centralized network and bringing these controls online required the combined efforts of the SCADA system provider and multiple engineering firms.

3. Objectives

The purpose of the project was to successfully commission each of the planned control systems in an effort to automate the plant's Dissolved Oxygen Control and Aeration Distribution systems.

4. Existing Process Description

The focus for this startup and troubleshooting narrative is a 6 GD Modified Ludzack-Ettinger (MLE) plant. The WWTP consists of preliminary grit removal and mechanical screening, followed by an activated sludge process, final clarifiers, and disinfection for secondary treatment.

The existing secondary treatment, a Modified Ludzack-Ettinger Process, is configured in 2 identical trains (Figure 1). Aeration air is provided by a trio of positive displacement blowers with airflow based VFD throttling. The air drop to each aeration zone is equipped with an airflow meter and an automated butterfly type valve with remote actuator.

The Aeration Control system commissioned is an airflow based DO control system which calculates target airflow setpoints for each process zone, passes a total airflow setpoint to the blower system, and initiates open/close actions to the system's automated control valves.

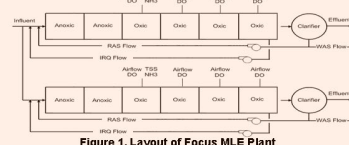


Figure 1. Layout of Focus MLE Plant

5. Commissioning Process and Troubleshooting Methodology

Communications/Networking:

Defining communication protocols and handshaking with remote systems presents a multitude of challenges. Limitations in the communication protocol complicated data transfer and design review meetings were required to fix both system architecture oversights and clerical errors.

Signal Processing:

Data quality is of paramount importance for all types of closed loop control systems. In particular, systems which employ feed forward techniques require data which has both consistency and continuity (smoothness) in order to be of practical use.

Lower quality data signals which would have otherwise caused process instability were conditioned through the utilization of proper wiring practices, employing higher sampling rates, and various software based filters and averages to remove noise caused by electromagnetic interference.

Backup logic was developed to allow the system to continue to function after the loss of a critical data source, due to equipment error. In the case of a lost airflow signal for a specific, valves continue to move in small increments open/close in an attempt to match the observed DO to the DO setpoint.

Valve Control:

Frequent start and stop commands sent to valve actuators shorten the life of equipment and can often cause unwanted perturbations in the process. During the course of startup it is fairly common to come across a valve actuator that simply does not work; in this case your system must be robust enough to compensate for the loss of air throttling to that control zone.

Developing a setpoint tracking valve control logic which provides for an acceptance tolerance helps to cut back on unnecessary valve modulation. Additionally a cv based algorithm was utilized to aid in the speed at which valves can zero in on their airflow setpoints, again reducing the number of actuations.

Blower Control:

Feedback control is among the most common types employed for blower control systems. However, instead of a more common pressure based feedback system the feedback metric employed at this plant was airflow. This allows the control and operators to directly manipulate and observe the poundage of air being provided to the process.

To achieve this feedback control, a PI loop provided by the blower system's integrator was employed in conjunction with some basic lead/lag and blower rotation logic. Through the course of the airflow setpoint tracking tests, it became apparent that the system was under tuned and bugs existed in the blower rotation logic which caused periodic drops in airflow provided to the plant. To rectify this, step response analysis was performed by the Biochem Personnel and Kp and Ki tuning parameters were recommended to the blower control provider to improve the blower's response. Additionally, attention was brought to the control provider's attention regarding the bugs in rotation logic, which was subsequently addressed.

Compensating for Process Design Limitations:

Actual influent flow values observed at the plant were approximately 50% of the design flow anticipated, leading to the partial shutdown of one train. Periodic aeration of the offline train was required to maintain diffusers, flow meters, actuators, and valves in working order— however this periodic aeration was a great disturbance to the controlled process train. To compensate for this frequent process disturbance, a modification was made to the total airflow setpoint calculation to account for air which was being pulled away from the process train.

6. Results and Conclusions

Communications/Networking: Communications troubleshooting was successfully completed; all Control data required was made available to necessary parties.

Signal processing: Low pass filters and moving averages successfully removed noise caused by the system's proximity to high power equipment (Figure 2).

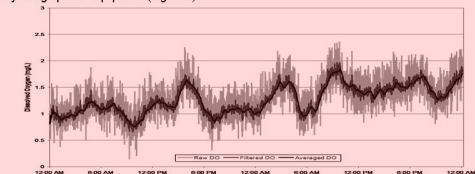


Figure 2. Signal Processing - Noise Reduction Methods

Valve Control

Techniques employed to maintain the health of the valves and the backup logic to compensate for valve failure have appeared to be successful. More data is required to fully test and tune and backup DO control logic.

Blower Control

PI tuning parameters suggested have been incorporated into the feedback control resulting in a stable and effective blower control system (Figure 3).

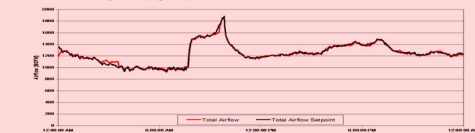
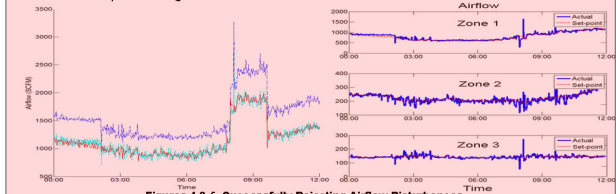


Figure 3. Successfully Tuned Blower Control

Compensating for Design Limitations: Figures 4 and 5 depict the successful implementation of the airflow compensation logic.



Figures 4 & 5. Successfully Rejecting Airflow Disturbances