SCADA: Shrinking Costs and Delivering Efficiencies

Vincent Hart, Chris Reinbold, and Lyle Munce

Supervisory Control and Data Acquisition (SCADA) has become universally accepted and utilized for remote monitoring and control in most water facilities. The water industry has done a great job incorporating SCADA into the day-to-day operations of a facility, but a poor job in leveraging this powerful tool to reduce labor, energy, and chemical costs. This real-world automation tool can give a utility lasting benefits

Pumping Systems: Pump Optimization Algorithm

Pumping systems in water treatment facilities can account for 90 percent of the power used. Focusing on pumping systems can result in significant cost savings without requiring significant expenditures. The use of a SCADA pump optimization algorithm to manage a high service pump system was used in a case study to keep the pumps operating at the best efficiency point over a range of discharge pressures. The result of the implementation of this algorithm was a 10 percent reduction in power use over the period analyzed.

When Should a Pump be Rehabilitated?

Knowing when to rehabilitate pumps can be a challenge. Finding a time when a pump test can be performed and dedicating the resources to perform these tests can also be a challenge. A better solution is to utilize the SCADA system to capture when these events can occur.

Programming simple calculations using data from measuring pressure level (determining total dynamic head), along with measuring and recording flows and using the pump affinity laws to back-calculate the speed if the pump is operating at less than 100 percent speed, can be combined to produce actual pump curve data points. Data points can be compared to the original pump curves to determine when a pump should be rehabilitated.

Wellfield Maintenance

The dynamics of wellfields allow SCADA to reduce work effort and provide energy savings. The specific capacity of a well is the amount of water produced per foot of drawdown in the well. Every foot of additional drawdown in a well is another foot of pump energy required for the well system to transfer water. Typically, wells are rated on the amount of water that they can produce, regardless of the drawdown in the well. A focus on energy efficiency means rethinking the concept of well capacity based on the well's specific capacity (and associated drawdown), rather than simply the amount of water a given well can produce. The desired wellfield flow rate divided by the sum of the total specific capacities of the wells provides a minimum drawdown of the wellfield. This minimum drawdown results in the least amount of static head required and is the first step in the energy efficiency analysis for a wellfield. Other factors, such as the pump efficiency at the minimum drawdown, water quality considerations (well water quality can drive treatment costs), water rights considerations, and variable frequency drive operation must be considered in the overall evaluation as well.

Wellfields can require a significant amount of investment in time and resources. One of the challenges associated with wellfield operation is performing drawdown to verify the performance of the well. The SCADA system can be automated to perform drawdown tests if the required instrumentation and recording information is in place. The current specific capacity can be compared to the original specific capacity to assist the utility with the decision of when to rehabilitate the well. The City of Manhattan, Kan., is currently incorporating these SCADA wellfield management features into its existing 30-mgd plant expansion project.

Vincent Hart, P.E., is vice-president with Carollo Engineers in Broomfield, Colo. Chris Reinbold, P.E., is project manager, and Lyle Munce, P.E., is vice-president with Carollo Engineers in Palm Beach County.

Chemical Feed Systems

The SCADA system can be programmed to incorporate features such as alerting the operations staff as to the days of chemical storage

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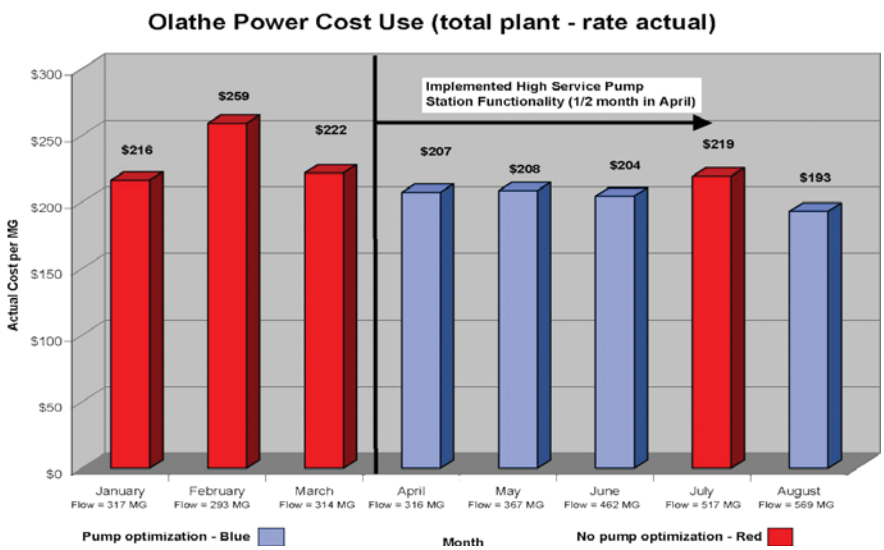

Figure 1. System operation with a SCADA-controlled pump control algorithm versus manual operation (no pump optimization).

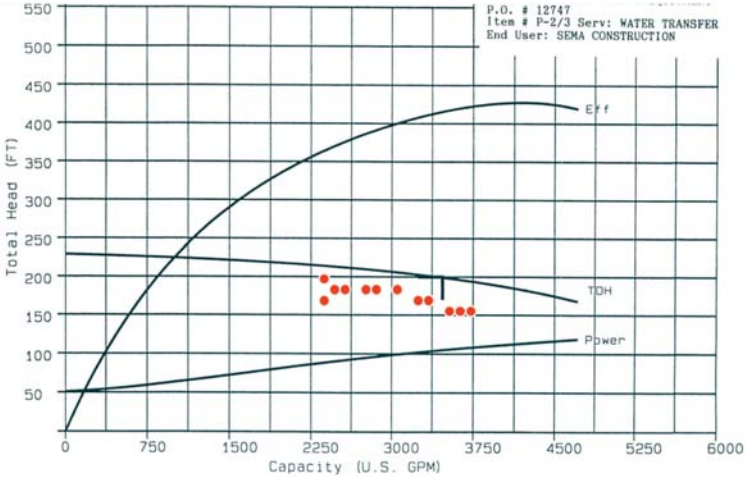

Figure 2. SCADA used to track actual operating conditions versus the original pump curve.

Figure 3. Utilizing simple math in SCADA, the drawdown of wellfields is optimized to minimize pumping costs.

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remaining based on the current dose of chemical and recent average flow rates. The predicted date when a chemical delivery (i.e., full tank truck) would be accepted could be highlighted, along with a follow-up reminder when the chemical system currently has the storage available to accept a delivery.

In addition to helping manage chemical deliveries, SCADA systems can be programmed to incorporate additional monitoring features to reduce chemical equipment requirements and alert operators to abnormal conditions. Instrumentation can create a "virtual day tank" on the SCADA system that informs the operator when and how much chemical has been used, if a significant change has occurred in the use rate, and when the virtual day tank needs to be refilled, which is accomplished by pushing the refill button on the SCADA screen. This system eliminates the need for an actual day tank, the associated equipment, and the space in the plant facility (a virtual spill is also much easier to clean up). Calibrating chemical feed pumps by comparing the prescribed dosage against the declining inventory also saves time and the hassles of employing calibration cylinders on a routine basis.

Residuals Management

In a recent project for the Water Environment Research Foundation (WERF), five wastewater treatment plants demonstrated an average of 20 percent reduction in polymer costs alone, while improving capture and cake solids concentration. Even though the project was for wastewater utilities, these lessons can be transferred to water treatment facilities as well. Excellent instruments exist for measuring solids, both in terms of infrared units for lower solids residuals, and microwave units for dewatered cake solids, with concentrations of up to 50 percent solids.

Reliable instruments to measure solids concentrations, if used properly, can reduce the polymer feed formerly required to keep the dewatering process from degrading when the operator is absent, or when the sludge concentration changes too fast to allow for manual correction.

Solids Contact Clarifier Operations

Solids contact clarifiers are the flagship of softening plants in the Midwest and in Florida. Although it is one of the oldest technologies in the water treatment industry, it is also one of the most misunderstood and neglected unit processes. Proper operating and control of solids contact clarifiers can be accomplished using a simple, straightforward algorithm for generating and maintaining the proper amount of solids in the center cone of a solids contact clarifier. The key to the operation of a solids contact clarifier is maintaining a solids inventory in the center cone of the clarifier. One of the most common misconceptions about solids contact clarifier operation is that the solids level needs to be above the outlet of the center cone (solids blanket mode of operation). A solids blanket is not required and can be detrimental to settled water quality (Figure 5).

The solids contact clarifier functions based on the principle that recirculating a significant amount of previously generated solids will continue to build and maintain a larger-sized solid, which provides a surface for continued chemical precipitation. These larger solids settle rapidly in the sedimentation zone of the solids contact clarifier and do not require a solids blanket for removal. Another popular misconception is that the only way to alleviate elevated torque levels on the rake of a solids contact clarifier is to waste solids. The problem with excessive wasting is that it reduces the solids inventory in the center cone, although it will reduce the torque on the rake. This will reduce the average size of the particles, which in turn will reduce the settleability of the solids and impact settled water quality.

The first step in alleviating elevated torque levels is to increase the speed of the turbine or center cone mixer. By doing so, the solids are lifted off the rake and the torque is significantly reduced. Part of the key to minimizing rake torque is to build larger solids, which will settle out quicker in the clarification portion of the basin. Solids that settle out closer to the center of the basin will result in less torque (torque is the load, times the moment arm; better setting decreases the moment arm). Based on input from operations staff from different softening facilities, a number of flowcharts have been de-

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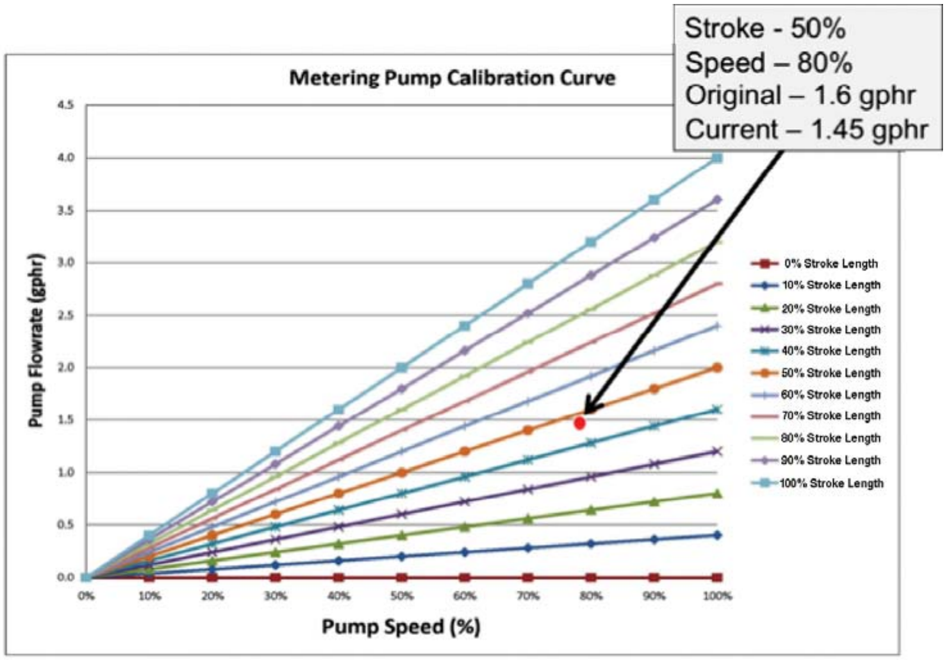

Figure 4. Calibrating chemical-metering pumps continuously and comparing actual chemical usage versus original calibration curves save time and continuously monitors metering pumps for problems.

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veloped to assist operators with procedures for managing high torque events, high turbidity events, and solids plugging events. To facilitate good solids contact clarifier operation, the optimum minimum operating speed of the turbine should be determined.

A popular misconception is that the turbine speed can be turned down to save energy. The problem is that slower turbine speeds will not lift larger solids off the bottom of the solids contact clarifier. This results in smaller particles in the system and a degradation of settled water quality. Poor settling equates to an inability to keep solids in the system and maintain a solids inventory.

If these simple operational philosophies appear to be so straightforward, why is it so difficult to operate a solids contact clarifier? The answer is revealed when the amount of solids in the center cone is compared to the amount of solids being removed by the solids contact clarifier over the course of a day. For example, the City of Manhattan needs to maintain approximately 18,990 lbs of solids in the center cone and will remove approximately 54,100 lbs over the course of a day. Small changes in the operation of the solids contact clarifier (e.g., solids withdrawal rates) can quickly result in large swings in the center cone solids concentration, thus making operation much more challenging.

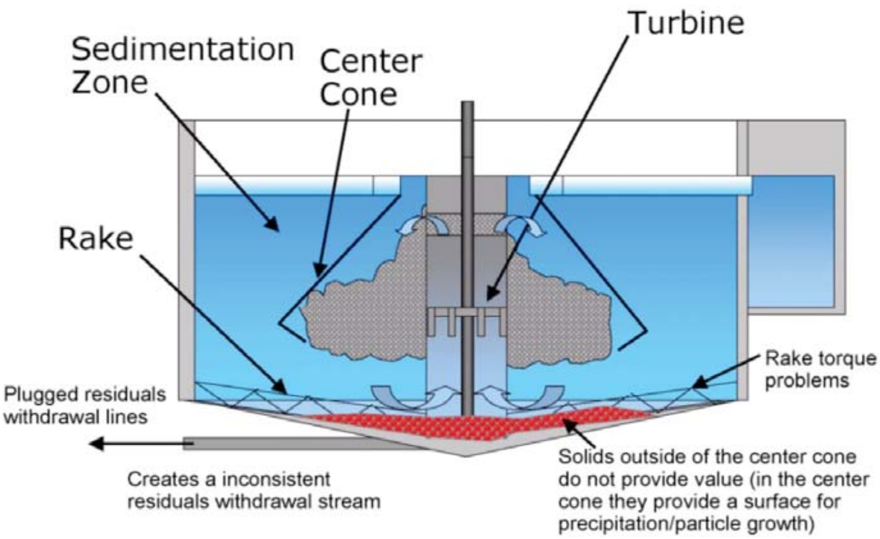

Figure 5. Operating solids contact clarifier with a solids blanket on the bottom can be detrimental.

Start-up of a solids contact clarifier is also a challenge, because when initially started, the particles are small and will carry over the weirs (or orifices) of the solids contact clarifier until they build up to a significant size (when they will begin settling out). This growth in particle size can take days. Once particle growth reaches this tipping point (starts settling), solids can accumulate very rapidly and potentially result in torque problems. The management of the percent solids in the center cone of a solids contact clarifier is the key to producing excellent settled water quality.

The typical recommended operating range of the center cone solids density is from 6 to 12 percent solids by volume. Using the average of this range (9 percent) and biasing the solids discharge duration based on the actual measured solids versus the desired average, an algorithm was constructed that automatically adjusts the solids in order to maintain the recommended percent solids by volume range. Prior to the implementation of this solids management program, the City of Manhattan was challenged to operate within the recommended range for more than four days due to the drastic changes in four key operational parameters: flow rate, influent hardness, effluent hardness, and lime dose.

After implementation of the solids management system, the solids were maintained within the recommended range continuously for over 100 days. Figure 6 shows a graph prior to the implementation of the algorithm; figure 7 shows a graph after the implementation of the algorithm.

Split Stream Softening Operations

Historically, Florida utilities have had to soften the entire flow rate in order to achieve

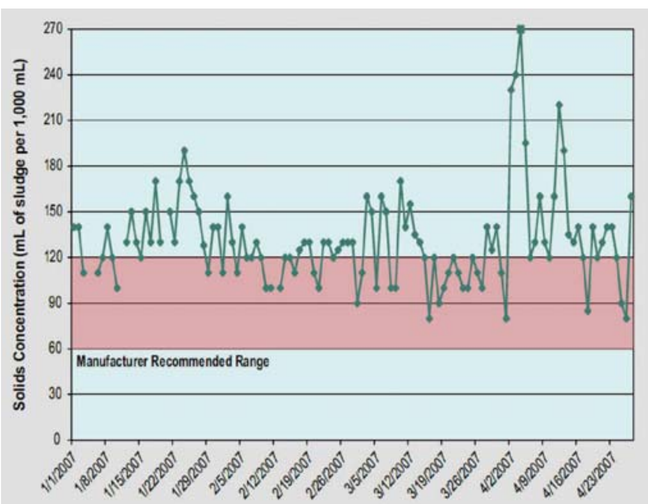

Figure 6. Solids concentration by volume prior to implementation of the SCADA algorithm.

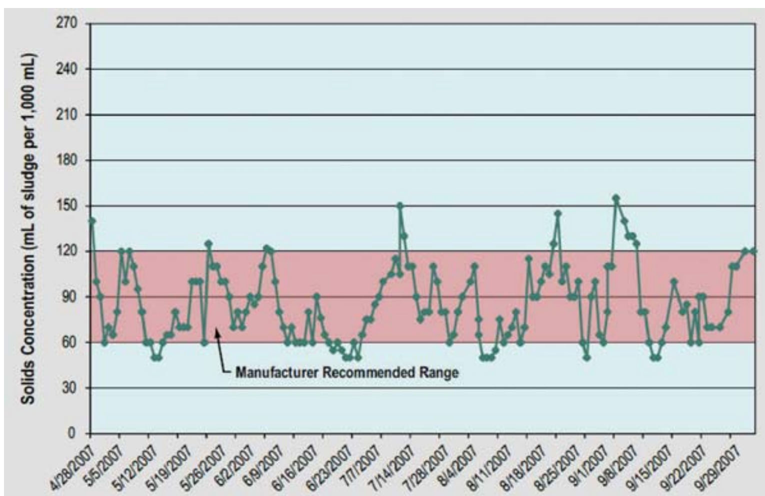

Figure 7: Solids concentration by volume after implementation of the SCADA algorithm.

both softening goals and organics removal goals. With the use of different organics removal technologies, the process of hardness removal has been decoupled from the organics process. This allows utilities to rethink their finished water hardness goals.

Palm Beach County is currently constructing a Miex® Ion Exchange System to assist with the removal of organics. The installation of this system at the front of the treatment process allows Palm Beach County to utilize a bypass treatment train in order to optimize softening. The ability to bypass will provide the County with the following benefits:

- "Dial-in" the finished water hardness to match the hardness goal.
- Increase the finished water alkalinity from 39 to 68 mg/L as $CaCO_3$.
- Decrease the settled water pH from 9.8 to 8.9 without adding any chemicals.
- Reduce the lime dose by 2,210 lbs/day.
- Reduce the residuals generation by 6,200 lbs/day.

One of the benefits that split stream softening provides is that optimization of the softening process is now a benefit instead of a detriment. Almost all Florida waters are limited in alkalinity, which is true of most surface waters or shallow groundwater. This means that softening is done until the alkalinity is gone and the softening process stops. This occurs during softening when lime addition results in an increase the finished water hardness, which is shown in Figure 8.

In order to optimize the softening process, it is beneficial to target and stay close to the point of minimum hardness (the point where alkalinity runs out). This allows a utility to bypass more water around the softening process to achieve the same finished water hardness goals.

In the 1970s, a utility in Mankato, Minn., utilized conductivity to optimize the softening process. It found that a conductivity probe would show this point of minimum hardness where the alkalinity was exhausted. Figure 9 shows the curve that was generated.

This same approach could be utilized by utilities that decouple the organics and softening process in order to optimize the softening process. Combined with the improvements to lime slaking systems, this could provide tight process control of the softening and bypass processes. When solids contact clarifier automation and optimization are combined with optimizing finished water hardness and improved lime slaking, the synergistic effects improve the overall plant operations, resulting in lower chemical and energy costs. ◊

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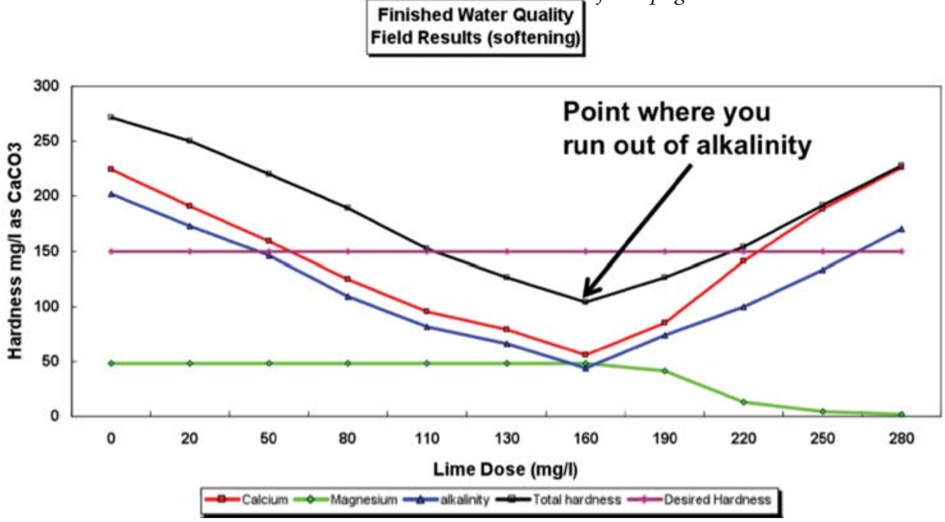

Figure 8. The point where alkalinity is gone is obvious because the finished water hardness increases with the addition of lime.

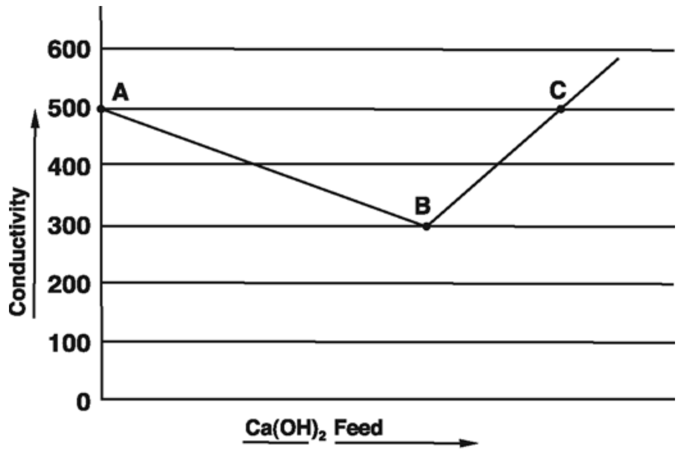

Figure 9. Plot of conductivity versus lime dose (Courtesy, AWWA Journal, 1970)

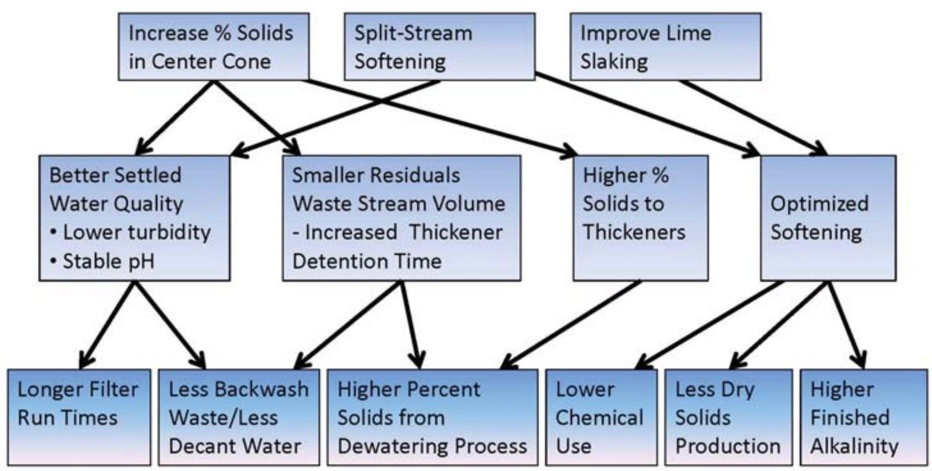

Figure 10. Integrating multiple optimization approaches to the softening process provides synergistic benefits resulting in improved plant performance and reduced operations costs.