Increasing the Value of Automation for Municipal and Industrial Wastewater Projects

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**Introduction**

In an uncertain economic environment, water/wastewater plants strive to be efficient, cost-effective and reliable. Every facility needs to maximize its performance and availability. For the economic operation of a wastewater plant, all of the various units must function together through optimally coordinated interfaces and automation systems.

Neglected or poorly performing water treatment systems can significantly reduce plant efficiency and reliability, increase chemical and energy costs, and trigger regulatory non-compliance. Too often, however, these systems suffer from a lack of adequate monitoring and control capabilities.

The following white paper discusses the use of modern automation technology to support wastewater projects at industrial and municipal sites worldwide. It describes the latest innovative strategies for automating water treatment units and other equipment assets in both new and existing facilities.

**Background**

Wastewater treatment is an important function that affects all of us: it is vital to keep our living environment hygienic and healthy, our watercourses clean, and our manufacturing facilities compliant with regulatory standards. Behind the scene, the wastewater treatment process combines microbiology and chemistry with mechanical engineering, instrumentation and automation techniques that offer high performance in a progressive way (See Fig. 1).

Waste treatment facilities face a number of trends that are having a broad impact on operations, maintenance, and capital expenditures, including increasing labor, energy, and chemical costs. Advanced process control is a tool that can help to minimize the impact of many of these trends. Automation of wastewater plants, where facilities run unattended for some period of time, is an essential element of a cost saving strategy. However, many plants have not implemented complete automation yet for a variety of reasons.

For those responsible for water treatment operations, the old rules governing automation technology investments no longer apply. Simply buying yesterday’s solutions (often, the least expensive equipment) isn’t the answer to progress. New approaches to process control have seized the day. Modern automation systems make it possible to measure, calculate,
estimate and monitor process efficiency, direct costs, lifetime costs, emissions — and all the interdependencies between them. They enable the plant to optimize and control its operations correspondingly.

The growing importance of automation requires project leaders to make a number of decisions. How can state-of-the-art control solutions improve the use of people and the structuring of work processes? What are the emerging technologies, and how do you lay the best foundation to support plant operations in the future while optimizing processes today?

**Business Challenges**

Purification of wastewater is of utmost importance to the health and well being of the population. While the science and mechanics of wastewater treatment are continuing to evolve, perhaps the biggest challenge is the fact that the set-up and maintenance of a water treatment facility must always be "local." One can’t set up a mega water treatment plant to serve the "eastern seaboard." Water treatment is a local problem and requires a local solution.

Due to various local conditions, the steps employed from one location to the next will differ. There is not a one-size-fits-all wastewater treatment processing plant that meets everyone’s needs. Moreover, there are many different types of wastewater treatment equipment units. Most of them have to do with aeration, mixing, settling, biological decomposition, airflow supply, waste flow, internal recycling flow, and other control parameters accordingly.

Today, it is imperative for wastewater plants to achieve their automation objectives both on time and within budget, while focusing on minimizing operational costs. Water treatment is “pump intensive,” often employing large motors using lots of energy. Reliability is also critical to the effectiveness of any water treatment facility. If automation systems and the processes they control are not dependable, the plant faces the risk of non-compliance with local, state or federal regulations. These demands are spurring new applications for software products, intelligent control systems, low-consumption components and site support services.

When water treatment plant owners think about improving their automation system capabilities, often their thoughts turn to the immense burden, risk and cost commonly associated with such projects. Upgrading automation systems shouldn’t be considered from merely a short-term perspective, though. When properly analyzed, the increased reliability, enhanced processing power and other long-term benefits often outweigh the time and cost invested today.

Rather than focus exclusively on the upfront cost of control system hardware and software, a growing number of wastewater facilities are partnering with experienced, knowledgeable suppliers dedicated to providing customers with long-term value from their automation technology investments.

**Operational Requirements**

Economy and reliability are paramount for wastewater plants. These facilities must be efficient in their construction and run day after day without a large maintenance staff. Energy usage is the second largest expense item at any type of water treatment site, often consuming 15-30% of the operating budget. Another big-ticket item is chemicals. The mission of the automation system is to reduce these expenses while improving regulatory compliance through automated reporting (See Fig. 2).
In the water/wastewater industry, there is the industrial side, getting water in and out of a plant for manufacturing purposes, and the municipal side, delivering fresh water to residents, and treating waste. The water treatment process itself is an interesting combination of mechanics and biology. It is essentially a high-stakes cleaning problem relying on screening, filtering and pumping as well as gravity and biology.

At a typical municipal wastewater facility, the process starts with the primary treatment where the influent sewage water is strained to remove all large objects and the oxygen level of the water is increased to facilitate microbe activities (microbes clean the water by feeding on its impurities). During this biological treatment phase, the microbes in the wastewater are given suitable growing conditions in terms of temperature, oxygen level and nutrition.

The next phase includes chemical secondary sedimentation, where chemicals are added to the water from the biological treatment to prompt flocculation of slowly degrading organic and other materials. In the last phase, the remaining sludge is treated by removing water from it. The water separated from the sludge is returned to the beginning of the treatment process, and the solid sludge is normally taken to a biogas plant (See Fig. 3).
When developing new wastewater facilities or upgrading existing sites, plant managers must find ways to automate all of the steps in the water treatment process — not just the main treatment units. Experience has shown that water treatment systems will produce more consistent, higher quality results if automated. They also need detailed information about how equipment is running in order to plan sound maintenance strategies and keep assets in excellent repair.

Advanced controls can help wastewater plants to:

- Centralize control room operations
- Schedule required maintenance based on timely reports and logs of critical parameters
- Improve process efficiency via coordinated control of pumps, motors and mixers

Once wastewater processes are effectively automated, a central monitoring station can be used to view equipment status, make changes to settings, collect historical information related to maintenance parameters, and run the operation in a more cost-effective manner with zero downtime.

**Latest Automation Solutions**

In order to ensure greater value and a lower cost-of-ownership from automation technology investments, Honeywell Process Solutions has committed to providing solutions its customers can “start with, live with, and grow with.” This approach is particularly applicable to end users in the water/wastewater industry, who are increasingly concerned about the long-term costs of maintaining their control systems assets.

Honeywell’s strategy enables plant owners to make smaller, incremental automation investments while at the same time moving to a next-generation automation system. Through the company’s “continuous technology evolution” policy, it provides the flexibility to deploy updated products, features, and functions with minimal risk to existing system investments.

In 2009, Honeywell introduced its next-generation MasterLogic line of high-speed, compact programmable logic controllers (PLCs) to meet the needs of customers with a wide range of process automation projects. MasterLogic offers all of the redundancy architecture options needed for most operations — and at a lower cost than other global brands. Its advanced technology brings higher speed processing and better control (See Fig. 4).

The MasterLogic solution provides the versatility and low cost commonly associated with PLCs and augments it with a global support network and the ability to integrate with the industry’s newest control systems. A versatile line-up of I/O modules and networking options (e.g., Modbus, DeviceNet, Profinet DP, etc.) enables flexibility in how the controller fits into an entire automation scheme. MasterLogic is designed to bring power and robustness to very high-speed logic, interlock and sequencing applications.
Key features of the MasterLogic system include:

- Powerful CPU (high processing speed, IEC61131-3 standard language)
- Redundancy options (CPU, power supply, and I/O network)
- Enhanced redundancy features including fast switchover time, high-speed synchronization and dual ring topology option
- Compact modular size (I/O dimension: 27m x 98m x 90m) for optimized cabinet installation
- Flexibility of network options (Fast Ethernet, Modbus ASCII/RTU/TCP, DeviceNet, Profibus DP)
- Variety of I/O modules including channel-to-channel isolation
- Interface option to communicate with third-party devices using user-defined protocol
- Robust diagnostics (system/error logs, system monitoring, network monitoring, ping test, and frame monitor)
- Integrated programming and engineering environment with SoftMaster
- Tight integration with Experion HS via dedicated protocol

Where industry standards have emerged, MasterLogic is in compliance. Instead of restricting the user to a solitary ladder programming language, the PLC is configured using the IEC 61131-3 set of languages so that it’s instantly familiar to the new generation of control engineers. MasterLogic empowers system designers with the flexibility to mix and match different programming languages in a single CPU with modular programs, each intended for a specific process control application.

In addition, Honeywell has released the Experion HS system to help fulfill the requirements of small to medium size unit operations. Experion HS is a powerful, yet affordable software platform incorporating innovative features for human-machine interface (HMI) and supervisory control and data acquisition (SCADA).

In wastewater applications, a MasterLogic PLC can be installed on treatment units and networked with an Experion HS supervisory computer. Honeywell’s ML server interface software allows the Experion HS supervisory software to have direct access to all memory locations in the MasterLogic PLC for use in operator displays, trends, reports, etc. (See Fig. 5).

Figure 5. In wastewater applications, a MasterLogic PLC can be installed on treatment units and networked with an Experion HS supervisory computer.
The MasterLogic/Experion HS solution contrasts with using the open Modbus protocol to integrate separate, off-brand PLCs and supervisory software, thereby requiring the engineer to perform a layer of mapping in order to access all memory locations. Such an approach is not only labor-intensive, but creates performance issues if the system becomes overloaded with other functions. What's more, the user must re-implement the mapping whenever the PLC and memory map have changed.

**Honeywell’s Integrated Approach**

MasterLogic is much more than just a better PLC; it comes from a company focused on the “system” of automation — not just the parts. Honeywell has always thought about automation problems in their entirety. Its holistic “systemness” strategy, first developed in the 1970s with the introduction of the distributed control system (DCS), supports an integrated architecture with unified sensing, control, operations and information management.

Thanks to systemness, the various elements of a plant automation system can be installed, started and operated together in a prepackaged manner without excessive tuning and adjustment by the implementation project engineer. Hardware and software components continue to operate with high reliability because they were engineered to be compatible. And when it’s time to expand or upgrade the system, that task is made easy as well.

The core aspects of Honeywell’s systemness include:

- Standard displays, faceplates and detail displays that provide a consistent look and feel to operators even when used with non-Honeywell controllers.
- Embedding of MasterLogic alarms and events into the Experion HS alarm and event sub-system, including Sequence of Event information.
- Critical functionality unifying the real-time, process-connected world of the controller with graphical user interface (GUI) and plant supervisory functions such as monitoring and alarm management.
- Data management functions that derive from history collection and reporting.

The Experion MasterLogic Server was designed with systemness in mind by providing supervisory software with access to actual read & write memory areas of the controller, rather than just internal memory. Plus, the unit’s configuration is automatically shown on pre-configured HMI graphics. There is also precise time coordination between the controller and the supervisory software. System alarms are generated and logged without any application engineering effort.

The Experion HS software supports systemness through pre-built standard displays (including process group, point detail, trend, alarm and set point programmer displays), which reduce configuration time. The software’s intuitive and flexible HMI meets even the most demanding requirements for process graphics, display navigation and alarm presentation. User-configurable pull-down menus and toolbars promote easier navigation to process data, and enhanced trending for up to 32 pens simultaneously and event markers provide operators with a comprehensive view of the plant. An on-board historian collects history and events, enabling instant access to reliable and accurate process information; and the use of open industry standards and the Microsoft Excel add-in provides greater flexibility in generating reports from process data.

Furthermore, Experion HS’s integrated configuration environment enables offline and online configuration changes and minimizes process disruption. Integrated server redundancy is provided without the need for expensive third party, fault-tolerant computing platforms.

**Wastewater Applications**

Honeywell’s approach to systemness in the realm of process automation can help industrial and municipal wastewater plants deal with a wide range of problems encountered in water treatment operations. Typical applications include:
A. Pre-treatment

The sewage stream arrives at the processing facility with all manner of large waste objects included. From plastic bottles to tree limbs, the first job is to screen these items out of the water. This is a mechanical screening and raking operation that is best controlled and monitored to assure downstream damage is avoided should these items enter further into the process.

The sewage stream is typically 99% water at the pre-treatment stage. To relocate this water from the surrounding community to the plant, and to move the water within the plant, requires various forms of pumping. The lift pumping operation runs the sewage through a series of pumps that moves the sewage from one elevation to another. The pumps are sequenced and make use of PLC control to do so. The related SCADA system will record flow rates and report these rates for both operational and regulatory compliance reasons.

B. Primary Sedimentation

Once the screening is completed, the water treatment process continues in a step where gravity does most of the work in a series of settling tanks. When the velocity of the water is properly controlled, stones, small debris and even sand and grit will sink to the bottom and exit the sewage stream. Some plants include a sedimentation tank where grease and oils are allowed to rise to the surface, and another skimming mechanism is used to remove these impurities. Settling tanks are usually equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper in the base of the tank where it is pumped to sludge treatment facilities. Raw sludge is collected and pumped to the next step in the process.

While the sludge is removed, the remaining wastewater is processed through clarifiers, which typically remove more than half of the remaining suspended solids from the wastewater.

Wireless HMI applications come into play throughout the sedimentation process. Visual inspection of the pre-treating equipment is an example.

C. Secondary Treatment

Gravity has done what it can to remove impurities, and now biology must take over. Again, there are different types of biological processes employed at different sites. A process that is frequently used is an activated sludge operation, whereby air and bacteria help remove waste from the sewage.

During secondary treatment, the sewage also passes through large trickling filters that include rock media as the filtering mechanism. The rocks are covered with treatment bacteria that rely on aerobic and biological removal of unwanted materials. Process control is important here to balance the dissolved oxygen content with active biologic material in order to support a productive cleansing process.

The water is then pumped into a series of anaerobic, anoxic, and aerobic basins. The basins effectively speed up the treatment processes of nature. Each step in the process is intended to select a certain bacteria and allow others to break down. As these bacteria absorb materials from the wastewater, they grow in size and eventually settle out as sludge. Some of the basins require sufficient dissolved oxygen concentrations, while other steps need the dissolved oxygen level to be near zero. Flow control valves are used and controlled by the automation system to maintain flow setpoints and to control the dissolved oxygen levels. Airflow and mixer speed are important controlled variables that modify oxygen content.

D. Disinfection

In some water treatment facilities, a disinfection step is added. Typically, this is done with chlorine. Many treatment plants could save chemicals and energy by implementing closed-loop control of chemical dosing. In the chlorination process, changes in flow and effluent quality result in a varying chlorine demand. If the automation system can match this demand,
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...savings are possible. Control of chlorine, therefore, requires accurate flow and chlorine residual measurements. Because chlorine dosing has a long dead time, the addition of a feedforward control can make for more accurate dosing.

E. Digestion

As indicated before, the wastewater treatment process produces sludge. This sludge must be further processed in what is called digestion. This is one of the more costly and chemically sensitive processes and so, again, good process control is a must. Some digestion operations are performed in a batch mode. Here, the process control system is especially useful in controlling the sequence of operations that successfully process each batch.

Conclusion

In the water/wastewater treatment industry, a growing number of plants are taking a long-term view of process automation that considers the overall value from technology investments — not just initial purchase price. Reliable controls ensure site personnel spend less downtime adjusting or repairing their systems. Instead, they can focus on running their plants more efficiently, developing strategies to reduce chemical and energy costs and improve regulatory compliance, and providing good service to their customers.

More Information

For more information about MasterLogic, visit our website at www.honeywell.com/ps or contact your Honeywell account manager.

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