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Optimize Water Cleanup with Activated Carbon

Follow a few pointers to make the most of your adsorption system

By Robert Deithorn, Calgon Carbon Corp.

TREATING AND reusing process water is a multidimensional challenge for process plants. Compliance with regulatory requirements to prevent and mitigate industrial pollution can require significant capital investment as well as ongoing maintenance outlays. The increasing scarcity and cost of fresh water for production processes also compounds the problem. (For insights on how major chemical manufacturers view water issues, see "The Tide is Turning," http://goo.gl/s9rVJW.) Ultimately, equally compelling pressures to address product purification needs, reduce the carbon footprint, and operate efficiently and profitably ratchet up the challenges.

The hard truth is that process plants need a practical solution that's economical and regulatory-compliant. For more than 40 years, no other method has offered better results for control of organic chemicals in liquids and gases than activated carbon adsorption. However, some plants undermine their treatment efforts. So, let's go over a few pointers.

DETERMINE THE BEST METHOD

Don't presume that one process can handle everything. Instead, put in time to identify the most appropriate technology for the job(s) at hand. A wide range of treatment technologies, e.g., reverse osmosis (RO), ion exchange and granular activated carbon (GAC), exist and can be used alone or in combination for industrial water treatment. The most-appropriate technology depends upon the feed water quality and effluent water purity required for a given application.

RO systems typically remove or reduce dissolved mineral salts, organics and other particles; they may require water

AVOID COMMON ERRORS

Plants potentially can compromise the life and efficiency of their GAC by making some all-too-frequent mistakes:

- *Installing an activated carbon system based on process assumptions without an actual pilot test.* Any trials should include appropriate comprehensive sampling and analysis so that the pilot can be meaningful and not simply raise more questions because insufficient results were obtained. Often the analytical costs will be the most significant portion of the pilot-plant costs.
- *Leaving spent carbon online for an excessive amount of time to save on change-out costs.* This can make the spent carbon unsuitable for reactivation due to contamination level and calcification.
- *Overlooking the potential need for prefiltration.* Undissolved contaminants and solids may limit access to the carbon and greatly reduce bed life. So, pretreat such streams to allow the activated carbon to focus on adsorption rather than having to contend with scaling or deposits.

pretreatment to protect the RO membranes against fouling, scaling or chemical degradation. Such systems usually incur higher investment and operating costs than a GAC system.

Systems with ion exchange resins can produce high-purity deionized water for reuse by exchanging the ions present in the water. The choice of resin depends upon the specific ions present. These systems typically aren't used to remove soluble organic species as GAC does.

GAC is a highly porous, high-surface-area adsorbent onto which contaminant molecules collect. It has an excellent track record as a cost-effective material for removing organic contaminants from liquids and gases. At process plants, GAC finds wide use in liquid and gas purification and to purify and reuse process water. GAC also meets regulatory requirements in wastewater treatment, groundwater remediation and for volatile organic compound (VOC) abatement in vapor-phase applications. GAC technology can help plants maintain emissions permit levels, meet state and local environmental requirements, and adhere to U.S. Environmental Protection Agency (EPA) guidelines and regulations such as the Resource Conservation and Recovery Act, the Clean Water Act and the Clean Air Act, particularly its National Emission Standard for Hazardous Air Pollutants program and benzene regulations.

Recycling or thermally reactivating carbon gives process plants the opportunity to reduce cost and waste, save energy, lower carbon-dioxide emissions and conserve natural resources while decreasing the long-term liability of spent-carbon disposal.

In fact, GAC has been classified as an EPA Best Available Technology (BAT) for removal of many organic contaminants. As defined by the EPA, "BAT effluent limitations guidelines, in general, represent the best existing performance of treatment technologies that are economically achievable within an industrial point source category or subcategory." That being said, how does a chemical company determine if GAC adsorption is the best technology to meet its organic contaminant removal needs?

SELECT THE RIGHT GAC`

A fundamental consideration is choosing the type of activated carbon that will deliver on your water purification and reuse goals. Virgin GAC is best reserved for initial system startup and reactivation of spent GAC (which we'll discuss later).

A standard, unimpregnated, bituminous-coal-based material made by the re-agglomeration method is used most often for adsorption of organic contaminants in industrial applications because it has a wide range of pore sizes to adsorb a broad variety of organic chemicals.

Re-agglomerated GAC is produced by grinding the raw material to a powder, adding a suitable binder for hardness, recompacting and then crushing to the specified size. Next, the material is thermally activated in a furnace using a controlled atmosphere and high heat. The resultant product has an incredibly large surface area per unit volume and network of submicroscopic pores where adsorption takes place. GAC has the highest volume of adsorbing porosity of any known material. Amazingly, five grams of re-agglomerated carbon have the surface area of one football field. Re-agglomerated carbon is generally preferred over direct activated because it's a more-robust material with a fully developed porosity, and at the same time has the necessary strength to withstand use and reuse.

To ensure optimal GAC adsorption operations, process plant installations typically include carbon adsorption equipment with the associated transfer piping. These systems can

Figure 1. Vendor usually handles the installation of fresh activated carbon.

be operated with single- or multi-stage vessels, depending upon the desired treatment objective. The adsorption system generally follows chemical clarification and filtration and precedes disinfection, if these steps are required.

Activated carbon can remove a variety of VOCs and semi-volatile organic compounds in one unit operation. It's important to fully characterize a stream prior to analyzing it for activated carbon purification. Information on a vapor-phase stream should include all VOCs and gases present, humidity concentration, temperature and pressure. All these factors will affect activated carbon performance. Similarly, characterization of a liquid-phase stream, including its ionic content and profile, types and concentrations of suspended solids, and pH, is crucial. Capacity tests that measure the mass of adsorbate removed per unit weight or unit volume of activated carbon then can measure adsorption effectiveness.

PILOT THE PROCESS

When considering a GAC system, a pilot plant study can determine if the technology will meet discharge permit requirements. Pilot plant testing of actual streams is the most reliable means to predict performance. Pilots should match the full-scale project equipment as closely as possible as far as superficial velocity, bed depth and empty bed contact time. For example, you can conduct an organic contaminant removal trial that uses a portable liquid-treatment unit and a liquid-phase GAC. Organics readily adsorbed by GAC include:

- aromatic solvents (benzene, toluene and nitrobenzenes);
- chlorinated aromatics (polychlorinated biphenyls, chlorobenzenes and chloronaphthalene);
- phenols and chlorophenols;
- fuels (gasoline, kerosene and oil);
- polynuclear aromatics, e.g., acenaphthene and benzopyrenes; and
- pesticides and herbicides, e.g., DDT, aldrin, chlordane and hepthaclor.

The pilot study also should quantify optimum flow rate, bed depth and operating capacity for a particular liquid or gas. This information is needed to determine the dimensions and number of carbon contactors required for continuous treatment. Other options also might be possible. For example, point source treatment of lower flows may provide a more-economical alternative than whole effluent treatment. Through use of computer predictive modeling or treatability studies, a supplier can determine if carbon adsorption technology can effectively reduce the concentration of the pollutants to levels that would allow discharge into the total wastewater stream — thus eliminating the need for more-expensive treatment methods for the total wastewater flow. By using these various studies and analyses, activated carbon manufacturers accurately can predict the viability as well as capital and operating costs of applying adsorption treatment, allowing you to compare these costs to those of other applicable technologies.

KNOW WHEN TO REPLACE THE GAC

During the carbon adsorption process, the available surface and pores of the GAC fill up with chemicals. At some point, the system no longer can meet the required performance criteria — often this is determined when the effluent quality from the carbon treatment vessels begins to approach the quality of the influent. The carbon is said to be "spent" and must be replaced. The spent carbon then either is discarded or recycled for reuse.

OPT FOR REACTIVATION

Three alternatives exist for dealing with spent carbon. The first is shipping it to a landfill or incinerator. However, this approach necessitates the purchase of new carbon and isn't the most environmentally friendly.

Regeneration via either a chemical or steam process may offer advantages over disposal in a landfill. However, this option generally is reserved for recovering and reusing a valuable adsorbate. It also is less efficient than reactivation.

The third option, high-temperature thermal reactivation, usually makes the most sense. The process destroys

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CONSIDER SOME SUCCESSFUL RECENT APPLICATIONS

One prominent chemical maker sought a cost-saving alternative to wastewater disposal. Specifically, it was looking for a way to reduce the organic chemical content of its process wastewater so that water could go to a water treatment unit at the plant. After evaluating the available options, the site installed a modular carbon-adsorption system configured as two adsorbers with connected piping; each adsorber contains 20,000 pounds of GAC and treats up to 100 gpm. Instead of using virgin carbon, the plant reduced its carbon footprint and costs by purchasing a large volume of reactivated-grade carbon and implementing an ongoing protocol for spent-activated-carbon reactivation by the carbon manufacturer. The chemical maker leased the carbon adsorption equipment from the carbon vendor, which also provided field service personnel for equipment maintenance and troubleshooting (Figure 1).

A major international chemical manufacturer wanted to reuse its process wastewater, so it could decrease its raw water intake from a nearby river and reduce its discharge volume to a local wastewater treatment plant. A principal concern was whether carbon adsorption could adequately purify the wastewater, which contained organic contaminants detrimental to the final product. After a trial test proved satisfactory, the plant decided on a modular carbon-adsorption system configured as two adsorbers with connecting piping, with each adsorber containing 20,000 pounds of GAC and treating up to 100 gpm. The purified wastewater was recycled to the process.

the adsorbed organic compounds and restores the GAC's adsorptive capacity. Reactivation can achieve up to 95% recovery of the virgin activated carbon's capacity. The reactivated material then can be blended with a small amount of virgin carbon to make up for the minor loss of volume.

Over the past few years, reactivation and reuse have surged in popularity at process plants for several reasons. From an environmental standpoint, reactivated carbon is considered an environmentally friendly product because reactivation produces only about 20% of the greenhouse gases generated in making virgin activated carbon. Moreover, GAC has a nearly infinite reactivation capability, so it rarely ends up in a landfill or incinerator. Reactivation is a logical choice for companies that incorporate sustainability in their long-term strategy.

Reactivation also delivers significant cost savings — it typically costs 20–40% less than purchasing virgin GAC. In addition, it ends the chain of custody for adsorbed contaminants, eliminating spent carbon handling and disposal liabilities. Some facilities may qualify to receive environmental credits issued by regulatory agencies for waste minimization because reactivated carbon is considered a recovered resource.

The profiling and testing processes to identify reactivation as an option are very straightforward. Depending upon the economics and volume of spent carbon produced, some plants may opt for onsite reactivation facilities. Those deciding to contract for off-site reactivation services should look for a vendor with the following field capabilities:

- spent carbon analyses;
- spent carbon removal and packaging;
- appropriate waste handling (hazardous or non-hazardous);
- transportation to the reactivation plant;
- carbon vessel inspection with minor repair; and
- vessel reloading with reactivated carbon.

TACKLING EMERGING APPLICATIONS

Carbon adsorption has treated some organic contaminants for more than four decades and is considered a mature technology. However, its role promises to expand as the EPA regulates additional chemicals. The agency maintains a contaminant candidate list of chemicals of emerging concern (CECs) that the EPA may consider for future regulation. Some carbon manufacturers like Calgon Carbon provide forward-looking assistance to chemical makers by monitoring the CEC list, offering a preview of what federal and state rules may require for treatment technologies, and conducting research and development to advance the use of activated carbon and treatment methods for removing CECs.

Every chemical manufacturer must contend with the ongoing demands of achieving regulatory compliance while maintaining operational profitability and creating high-quality products. For organic contaminant removal from liquids and gases in process applications, GAC remains a proven, reliable way to satisfy environmental management demands and product purification needs. Furthermore, use of reactivated carbon instead of virgin carbon offers additional cost efficiencies and environmental benefits. ●

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Improve Plant Performance with Solids/Turbidity Monitoring

Continuous monitoring in the liquid processing stages of a wastewater treatment plant offers important benefits

By Andy Archer, Hach Co.

ONCE WATER has served its purposes within an industrial plant, it must be treated for reuse, environmental release, or discharge to a public wastewater utility. Many kinds of sewage can enter an industrial wastewater treatment plant including chemicals, oils, greases, metals, and storm water just to give a few examples. This waste is treated using a series of stages to cleanse and disinfect the water prior to reuse or before safely returning it to the environment. Solids management is critical to ensure that the industrial wastewater treatment plant is both meeting its discharge targets and operating efficiently. This article outlines the key liquid processing stages used in wastewater treatment and the potential impact that continuous solids/turbidity monitoring can provide.

BENEFITS OF MONITORING SUSPENDED SOLIDS/TURBIDITY

Monitoring suspended solids/turbidity in the liquid processing stages of a wastewater treatment plant offers these important benefits:

1. Improves plant efficiency by providing stability and continuity to the treatment process.
2. Continuous on-line monitoring reduces the need for time-consuming laboratory analysis.
3. Real-time monitoring provides more accurate process control.
4. Monitors compliance with limitations placed on the concentration of solids entering and leaving the plant.

TYPICAL WASTEWATER TREATMENT PLANT

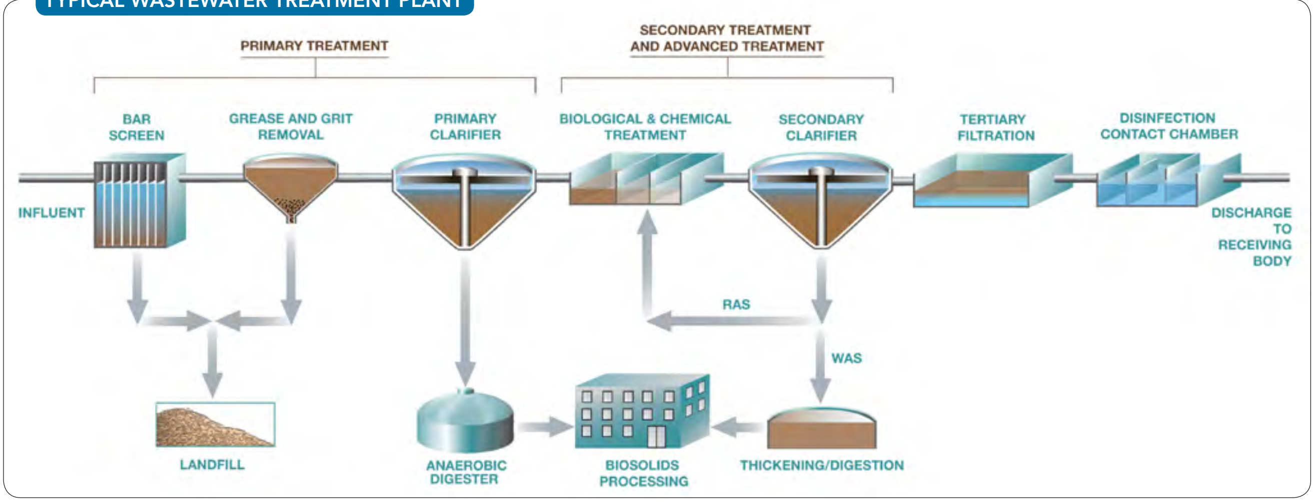

Figure 1. The above illustration shows the basic arrangement of typical a wastewater treatment plant.

Figure 1 shows the basic arrangement of typical a wastewater treatment plant.

The typical liquid processing stages used in a wastewater treatment plant are:

- Preliminary Treatment Stage
- Primary Treatment Stage
- Aeration Basin Stage
- Secondary Clarifier Tank Stage
- Return Activated Sludge (RAS) Line
- Waste Activated Sludge (WAS) Line
- Nitrification Basin Stage
- Final Filtration, Disinfecting and Plant Effluent Stage

PRELIMINARY TREATMENT STAGE

In this stage, evenly spaced bar screens are used to initially remove large debris such as rags, cans, leaves and sticks while the wastewater passes through. After the debris is removed, it's taken to a landfill or incinerated.

PRIMARY TREATMENT STAGE

After pretreatment, the wastewater moves into a grit chamber to reduce the flow, allowing sand, grit, and other heavy solids to settle to the bottom of the chamber. These settled solids are removed and sent to a landfill. The wastewater continues into the primary clarifier tank, shown in Figure 2, in which the average detention time is approximately two hours. During this time, grease and scum are allowed to float to the surface and be removed by a skimmer. Also, any remaining solids settle to the bottom of the tank. This watery solids mixture, called primary sludge, is then scraped into a sump and removed. The concentration of this sludge and the rate at which it is removed from the primary clarifier depends on the type of solids handling equipment being used. If the sludge is being pumped to a digester, it is typically a thicker sludge with a concentration of approximately 5%. Conversely, if the first solids handling unit is a gravity thickener, fresher solids in a thinner sludge concentration (0.5% to 1.0%) is essential.

Monitoring suspended solids content in the primary discharge pipe helps to automate the primary sludge discharge. The goal of control at this stage is to thicken the sludge in the funnels of the primary settling tank as much as possible. Proper control ensures that the sludge will not become anaerobic and helps avoid a discharge of primary sludge into the activated sludge stage. It also guards against a water breakthrough to the biosolids treatment stage. Monitoring suspended solids concentration enables the operator to close the sludge discharge valve when a predetermined sludge concentration is reached, instead of depending on detention time in the primary clarifier.

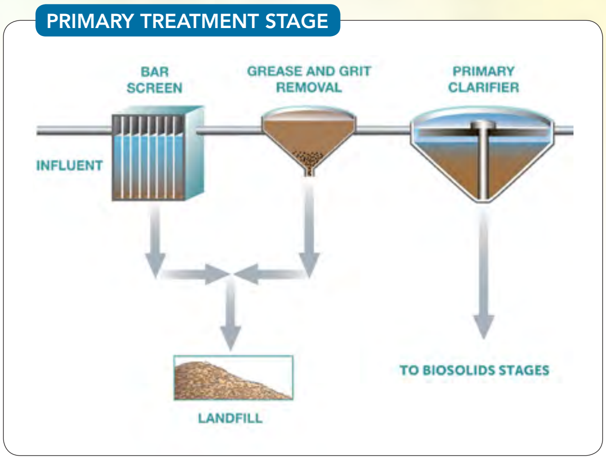

Figure 2. In the primary clarifier tank, grease and scum float to the surface and are removed by a skimmer.

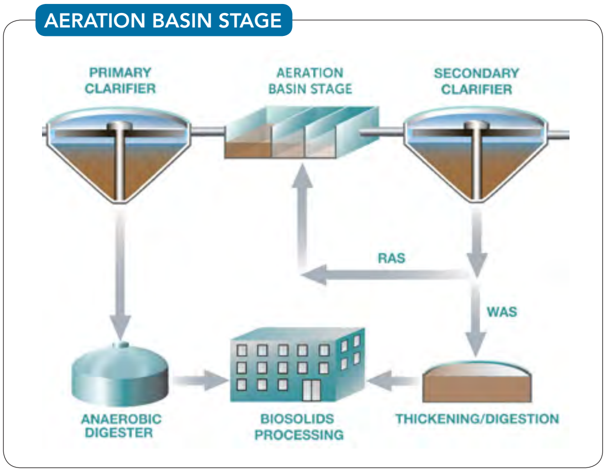

Figure 3. Activated sludge is taken from the bottom of the secondary clarifier and split into two different flows.

AERATION BASIN STAGE

The effluent from the primary clarifier is step-fed to the aeration basin where it is mixed with the RAS from the secondary clarifier. This return sludge is a biomass or blend of beneficial microscopic organisms, bacteria, and solids that converts the non-settleable solids (dissolved and colloidal matter) into settleable solids, carbon dioxide, water and energy.

The mixture of primary clarifier effluent and return sludge, often called "mixed liquor," fed to the aeration basin, shown in Figure 3, is now mixed with air through diffusers located along the bottom of the basin. This air produces the turbulence to mix the biomass with the primary effluent, and provides the needed oxygen to sustain the biomass.

Monitoring suspended solids content in the aeration basin helps to ensure that the proper amount of biomass is present. This saves energy without risking inefficient organic pollution removal. Too much biomass in the aeration basin causes excess air to be added, wasting energy. Conversely, too little biomass forces inefficient removal of the organic pollution that is present. Controlling the suspended solids content in the aeration basin also allows the operator to adjust the process based on changing plant loading conditions.

SECONDARY CLARIFIER TANK STAGE

The aeration basin effluent (also called "mixed liquor") is transferred to the secondary clarifier. Here, the activated sludge settles to the bottom and the clear effluent is pumped to nitrification basin. The activated sludge taken from the bottom of the secondary clarifier is split into two different flows, as shown in Figure 3. The WAS is removed to maintain the correct biomass population. The remaining RAS is returned to the aeration basin for reuse.

RETURN ACTIVATED SLUDGE (RAS) LINE

Controlling waste sludge rates helps the plant run more efficiently. This can be accomplished many ways, but most plants choose to keep their mixed liquor suspended solids (MLSS) concentration in the RAS line within a specific concentration range.

A variety of mechanical controls can be used to set and maintain the RAS concentration and flow rate. The most common and simple control method is to operate with a constant pumping rate throughout the entire 24-hour day. By using a constant pump speed, the solids in the secondary clarifier will change as the incoming plant flow rate changes. During the day, the flow is higher which tends to push the solids into the clarifier. At night, when the plant flow rate is lower, the RAS line will feed solids back to the aeration basin faster than they are entering the clarifier. This control method provides a continual daily shifting of solids. An alternate control method is to use a variable pump speed that changes as the plant flow rate changes. The logic behind this control strategy is that as the plant flow rate increases, more aeration basin solids are pumped into the secondary clarifier. Unless the RAS flow rate is increased during these time periods, the clarifier may build up an excessive solids balance (as evidenced by high sludge blankets) resulting from the increase in solids detention time.

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Generally, this control method works well. It also has the added benefit of assisting the operator during periods of slow and rapid settling sludge by allowing a change in the percent return during the day to better match the settling rates being experienced in the clarifier. The best proven control method uses a suspended solids sensor mounted in the RAS line to provide continuous measurement of the solids concentration. This method provides better control because it can slow down or speed up the RAS flow based on the actual concentration in the RAS line, not the incoming plant flow.

WASTE ACTIVATED SLUDGE (WAS) LINE

How efficiently the RAS line is controlled directly affects the amount of sludge being wasted. Regulating the amount of WAS is the most dramatic control the operator has available to change the sludge and effluent quality. Through wasting, the operator has direct control over the inventory of sludge carried in the aeration and clarification systems. The solids inventory level will either increase or decrease with a corresponding decrease or increase in waste sludge quantities. Any change in sludge inventory will also specifically change the sludge characteristics and the relationship of the biomass population to the available influent food supply. It is this direct control over sludge characteristics that makes waste sludge control and the resultant solids inventory very important to efficient plant operation.

NITRIFICATION BASIN STAGE

As previously stated, the effluent from the secondary clarifier is pumped to the nitrification basin where chemicals are added to provide additional alkalinity, raising the pH of the wastewater. A long detention time encourages a different type of bacteria to develop in the biomass. This bacteria converts ammonia nitrogen to nitrates, a form of nitrogen that does not deplete oxygen from the receiving stream.

FINAL FILTRATION, DISINFECTING AND PLANT EFFLUENT STAGE

The nitrification basin effluent flows into a mix tank where aluminum sulfate (alum) is added to precipitate phosphorus. This is followed by adding polymer and flocculent to improve settling characteristics. The effluent is then polished by a gravity filtration process typically consisting of anthracite coal and/or sand filters. The effluent from the gravity filters is disinfected with chlorine and aerated to increase the dissolved oxygen in the water. Finally, it is dechlorinated with sulfur dioxide and released from the plant.

Depending on the plant size and population served, state governments impose limitations on the concentration of solids leaving the plant. Consequently, most plants are required to monitor suspended solids concentrations in the plant effluent to comply with permit requirements. Monitoring turbidity at the final discharge of the plant ensures compliance with any limitations placed on the concentration of solids leaving the plant.

PROPER SLUDGE REMOVAL

Within the liquid processing stages of a wastewater treatment plant, activated sludge oxidizes the organic wastes using beneficial bacteria. This is followed by separating the suspended solids from the treated wastewater. The goal of the wastewater treatment plant is to break down the sludge and separate it from the wastewater. When too much sludge accumulates at designated checkpoints, the plant becomes overloaded, and the sludge is not properly treated. When too little sludge is used within the plant, it is not operating at maximum efficiency and energy may be wasted. Hach's versatile suspended solids/turbidity measurement systems are ideal for monitoring solids throughout a wastewater treatment plant to improve plant efficiency through more accurate process control. ●

ANDY ARCHER is application development manager for Hach Company. He can be reached at aarcher@hach.com.

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Simplify Pump Protection

A variable frequency drive can reduce installation and programming costs and provide a host of other benefits

By Steve Petersen, Yaskawa America, Inc.

FOR SOME unbeknownst reason, engineers and technicians in the motor control industry associate a programmable logic controller (PLC) as being a necessary component for variable frequency drive (VFD) control. This may have rung true years ago, but VFD technology has progressed and made technological leaps and bounds just as much as other technologies in recent years. VFDs have reached the maturity level that eliminates the need to install and program a PLC which was previously needed to make many applications function. This advancement results in overall cost and space savings. Additionally, wiring and programming complexity is reduced significantly.

A very common example where a VFD can step up to the plate and take over the functionality of a PLC, is a pumping application. Many pumping applications run a PID loop to determine required motor speed. Simply put, a PID loop will consist of a set-point, feedback, and tuning for the PID loop. Frequently, a PLC is utilized to process the entire PID loop and simply output an analog speed reference to the VFD.

In this case, the VFD is being underestimated since most entry-level VFDs have their own PID loop which can be enabled and setup with only a small handful of parameters. The set-point is entered directly into the VFD's programming. This eliminates the need to juggle between the VFD's keypad and a PLC's often pricey computer software. Feedback from a transducer is landed directly to the VFD's analog input.

With these two commanding values input, the drive can now determine if the motor should speed up or slow down to meet the set-point. This maximizes energy efficiency; the motor is only running fast enough to meet the demand of the current set-point value. Cost is lessened as a PLC doesn't need to be purchased or programmed. Also, space is dramatically reduced because the entire process runs off of the VFD.

A PID process loop is a relatively simple example which only scrapes the surface of the potential processing power of a VFD. Sticking with pumping applications, VFDs can protect the pump motor and the application with a minimal amount of programming needed. On a specialty pump VFD, protection can be setup in three basic steps; level, delay and action (Figure 1).

The level is a value at which point a protective feature is triggered. This level can be based on current, frequency, voltage, feedback, etc.

The delay will determine the amount of time the value being monitored can stay above or below that point before action is taken.

After the delay time expires an action is taken. This action includes, faulting out the VFD, alarming, or closing a digital output contact on the drive.

The VFD has the ability to monitor current, frequency, feedback, voltage and many other critical values. The ability

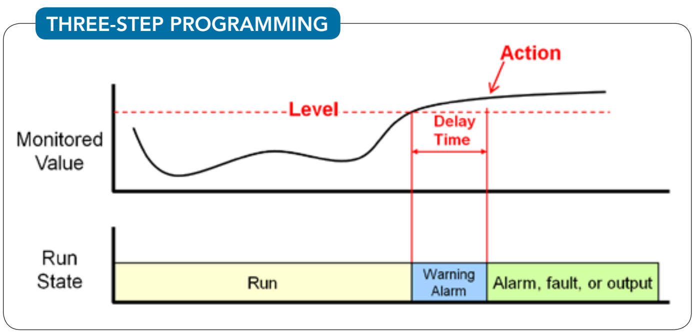

Figure 1. Most VFD protective and application-specific programming can be broken down into three parts; a level, delay and action.

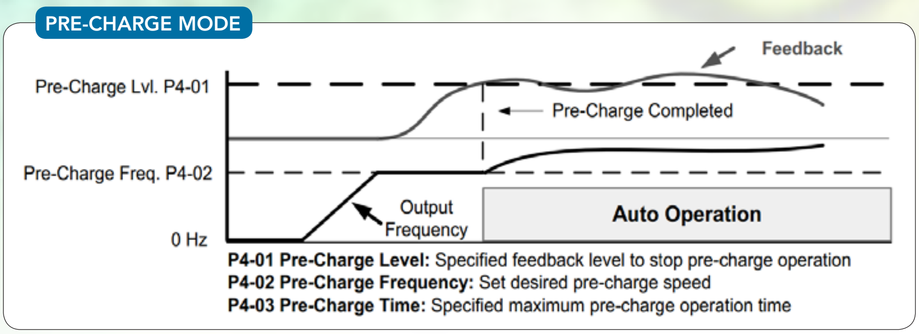

Figure 2. The VFD ends pre-charge once the maximum pre-charge time expires or the pre-charge level is met.

to monitor these values also gives the VFD the ability to protect countless VFD and pump-related components, which can avoid potentially hazardous running conditions.

Consider a condition where prime is lost on a pump's suction side. The simplest and most effective way to determine that prime has been lost is to monitor the current drawn by the pump motor. To protect the pump from a loss of prime occurrence, a motor current detection level in the VFD must be set just above the motor's no load current. The reasoning behind this is that if prime is lost, the current drawn by the motor will be reduced. If the output current drops to the no load current, which is right below the set detection value, the VFD will perform the desired action after the programmed delay time. This protects the pump from overheating due to the dry run without the need for additional components.

Those three basic programming steps (level, delay and action) for loss of prime are copied and pasted throughout the majority of a VFD's programming. Another example would be some form of high pressure relief or detection which is a necessity on any pump application. With a pumping VFD, a high feedback level can be programmed into the VFD. Following suit, a delay time and an action for this new condition must be set. Once properly set up, if the system's pressure were to reach the high feedback level the VFD can halt pump operation before damage occurs. The VFD also can be programmed for a low feedback detection situation that functions in the same fashion.

In addition to providing protective features such as loss of prime and high and low feedback levels, VFDs offer a wealth of programmable functions that can provide a variety of benefits for different applications. Irrigation systems commonly consist of long and intricate lines of plumbing. When an irrigation system is operating, it's important to first pre-charge the system. Pre-charging simply means running the VFD at a relatively low fixed speed to slowly fill or pressurize the system. Pre-charging is beneficial as it will eliminate any hammering of valves which occur with an otherwise fast pump speed.

Setting up the pre-charge function only requires three parameters to be programmed, just like the aforementioned features. For pre-charge, a fixed frequency must be determined. This frequency is called the pre-charge frequency and is the frequency at which the VFD will run while in pre-charge mode. Pre-charge mode will activate when a VFD receives a run command. Pre-charge will run at the programmed pre-charge frequency until one of two criteria is met (Figure 2).

This necessitates the requirements of two additional parameters; the pre-charge level and pre-charge time. The sole function of these two parameters is to end pre-charge. The pre-charge level uses the transducers feedback to determine at what level to end pre-charge. This usually is in pounds per square inch (psi). Alternatively, the pre-charge time is the maximum time the VFD can run in pre-charge mode, regardless if the feedback level is ever reached.

These examples are just a sample of a VFD's true potential as far as protective functions and application specific features. Though all of these features and parameters may seem overwhelming, keep in mind the consistency with parameter set-up. Also weigh in the potential space savings and resultant money savings by eliminating unnecessary PLCs and additional hardware. ●

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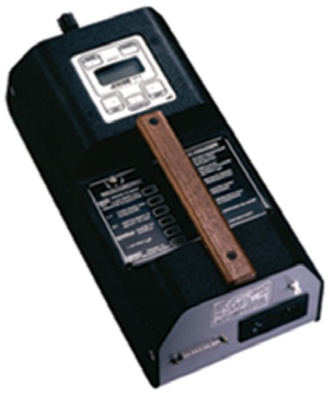

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Solve Partially Filled Pipe Flow Measurement Challenges

An electromagnetic flowmeter helps provide crucial process information at two wastewater treatment facilities

By Rich Lowrie, KROHNE, Inc, and David Spitzer, Chesapeake Flow Solutions, Inc.

IS THE magmeter half full or half empty? That interesting twist on an old cliché is an apt question to ask the people of a certain small Pennsylvania city. The town is located in Schuylkill County, Pennsylvania, smack in the middle of the state's Coal Region, named for the abundance of anthracite coal first discovered in 1790.

With a little bit of background, the reasons for posing the half-full/half-empty question become abundantly clear. The town was experiencing a serious problem with wastewater overflow — not a complete surprise, given that the sewers themselves had been built back in the 1800s. These were not plastic or even metal pipes; the four-foot-diameter pipes were built out of good, old-fashioned masonry.

For as many years as anyone can recall, raw sewage was transported via the sewers and dumped straight into an open creek. Due to environmental concerns, state and federal regulations required the water be treated before being discharged. Consequently, in the 1970s, an interceptor pipe was installed, which would grab a portion of this flow and send it to a recently built wastewater treatment plant.

Although the interceptor pipe remedied some of the problem, the solution had a serious flaw. The issue arose whenever there was a sizable rainstorm; in such instances, the interceptor system would bring an overabundance of storm overflow to the plant, which wasn't designed to handle the increased water volume. As a result, the plant would flood out, leading to some unpleasant scenarios — legal and otherwise.

"During high water events, the wastewater treatment plant was being flooded out, causing untreated or partially treated water to enter nearby streams," said Richard Lowrie, water and wastewater industry manager for KROHNE, a global technology leader in the development, manufacture and distribution of accurate, reliable and cost effective measurement instrumentation for the process industries. "This would result in fines from the state regulating agencies, not to mention the unfortunate impact on the environment."

Obviously, nothing could be done to change the weather, so, a solution had to be devised that would control the flow of water to the wastewater treatment plant, particularly during heavy storms. The key would be regulating the initial flow of water into the interceptor system that fed the wastewater treatment plant.

To design a viable solution, the city turned to Buchart-Horn of York, Pa., a full-service engineering and architectural firm. The firm answered a request for proposal (RFP) to perform an update of the city's 537 Plan. (The Act 537 Program, the Pennsylvania Sewage Facilities Act, was enacted on January 24, 1966. Its purpose is to correct existing sewage disposal problems and prevent future problems.) To meet this objective, the Act requires proper planning in all types of sewage disposal situations.

"The 537 plan is approved by the state Department of Environmental Protection," said Bruce Hulshizer, a senior engineer with Buchart-Horn and a project manager for sewer and water projects. "That's basically saying 'This is what we're going to do for our sewer needs.' Apparently, the DEP wasn't satisfied with the way things were going and they weren't going to meet their consent order, so that pulled us in."

As part of the solution, Buchart-Horn brought in KROHNE to provide a technical component to address improvements needed to the collection system; that component would form the centerpiece of the answer to the earlier half-full/half-empty question.

The component consisted of partially filled electromagnetic flowmeters (magmeters) to measure the lower normal flows and the higher flows during high water events. By using partially filled magmeters, the city is able to measure the normal flows, which would not keep a typical magmeter filled and also handle the higher flow rates in very rainy conditions. This would mean that the storm water flow in high-water events could be diverted away from the plant and into nearby waterways, solving the issue of plant overload. (When the flow rates reach a preset flow, it is assumed that flow would consist of storm water run off and thus, can be safely diverted away from the treatment plants.) When normal flow rates resume, the flow is then directed back to the treatment plant.

"The city had a combined system, comprised from storm water and sanitary flow," said Hulshizer. "In order to have such a system, you have to have control structures that basically separate sanitary flow out away from a pre-designated amount of flow. After that, it would be storm flow, so you'd have to have some way of dividing the two. That's where partially-full magmeters came in."

All KROHNE magmeters are wet-calibrated by direct comparison of volumes. This translates to a high accuracy — up to ± 0.2 % of actual value.

For this project, Buchart-Horn chose 21 of KROHNE's TIDALFLUX line of electromagnetic magmeters. These factory-calibrated flowmeters are combined with a capacitive flow-level measuring system, built into the wall of the measuring tube, thus providing accurate flow measurements in partially filled pipelines, with levels between 10 and 100% of the pipe cross-section. The flowmeters' steady display of measured values is achieved regardless of rough product surfaces and distorted flow profiles.

Two different manufacturers bid on the project, but KROHNE was the only manufacturer able to supply magmeters in the larger diameters necessary for the project. KROHNE also has an existing installation base to use as a reference for performance of partially filled magmeters.

In the end, the load on the wastewater treatment plant has been substantially reduced in high water events, allowing the plant to operate within its specified ranges. In addition, the environmental impact of nontreated or undertreated water entering the streams from the plant has been greatly reduced.

"It's been a long process to where the city has come in terms of its wastewater treatment, but it has been a very effective solution," said Hulshizer. "And the KROHNE magmeters proved to be a critical element." Which of course means that if you ask the city whether the magmeters are half full or half empty, you know what the answer will be.

ACCURATELY MEASURE HALF-FULL PIPES

Some people look at the glass half full, some look at it as half empty. Neither approach is inherently bad; it's just two different ways of looking at things.

However, if a pipe in a wastewater treatment plant is only 50% filled, it doesn't matter whether you call it half full or half empty. When it comes to measuring the liquid in that pipe, either way presents a significant problem. The dilemma comes down to one undisputed truth: few instruments can accurately measure the level of flow in a pipe that is half full — or less.

Primnath Rambissoon, instrumentation supervisor at the Back River Wastewater Treatment Plant in Baltimore, was all too familiar with this issue.

"We had a process in the plant that had been shut down for quite a while, and when we restarted it, we had problems taking the measurement in that pipe," said Rambissoon, who

also is in charge of the plant's remote pumping stations and remote media stations. "It was an application where the flow rate was very low and the pipe wasn't completely full. Unfortunately, the flowmeter we were using was simply unable to measure flow when it was that low."

Specifically, the trouble area was a section of piping that served as part of the plant's sludge-handling process, transferring liquid from one section of the plant to another. The root cause was that the 12-in. pipe was oversized for the amount of material running through it: plant management had previously attempted to remedy the situation by installing a reducer to reduce the pipe from 12 in. to 8 in., but that still wasn't enough to make the existing flowmeter work. Essentially, where the water originated at the entry point of the plant was a full pipe and the meter there could handle the flow rate. But plant personnel were unsuccessful trying to correlate that flow with what was coming from the other side of the plant.

"When I came here about three years ago, operations told me about it, but there was nothing I could really do without a full pipe to read," said Rambissoon. "It would just run and they would look at it when they got flow and they would just guess much of the time.

"What's worse, since we couldn't get a flow, we couldn't operate on automatic mode in that process, which would have reduced our operational costs. We operated in manual mode for years, probably from the time the system was designed."

According to Rambissoon, the flow measurement in this section of the plant didn't present any environmental or health dangers. At worst, it might lead to a situation in which tanks might be overfilled, causing leakage somewhere else in the plant. Still, accurate measurement was — and still remains — important to the plant's overall efficient operation.

Then, late in 2008, David Spitzer of KROHNE, Inc., a global leader in the design, development and manufacture of innovative and reliable processes, was making one of his regular sales calls to Back River. Spitzer, KROHNE's district sales manager at the time, informed Back River that KROHNE had a product capable of measuring flow in partially filled pipes.

Rambissoon was intrigued by this prospect and decided to investigate further. Working with KROHNE would not be a real leap of faith, given that Back River already had a relationship with the company (the plant had recently purchased a couple of KROHNE's OPTIWAVE 7300 C Radar Meters, one of which is being used to measure the level of a basin in the chlorination/dechlorination section of the plant). What's more, some of the meters in the plant were actually KROHNE flow meters, although they were pushing 20 years old.

"I did a little 'show and tell' on our meter products and it really clicked with Primnath," Spitzer recalled. "He was very interested in getting our flow meter into that low-flow pipe to see what it could do."

As a result, Back River bought the KROHNE TIDALFLUX electromagnetic flowmeter at the end of 2008; it was delivered and installed in early 2009. The flowmeter, which is ideally suited for use in partially filled pipelines, is installed mainly in the intake and outfall structures of sewage works and stormwater basin outlets, as well as in transfer stations.

The measuring system is similar to that of a conventional electromagnetic flowmeter with two measuring electrodes, supplemented by a capacitive level measuring system which measures the filling level in the primary head with millimeter accuracy, regardless of whether the pipe is flowing full, half-full or even less.

As the two measuring electrodes are located below the 10% filling level, the TIDALFLUX is immune to any residues floating on the water surface and is not affected by flow profile or wave motion. The capacitive level measuring system is supported on large-area sensors that are embedded in the liner of the primary head. Thanks to this capacitive principle the measurement is less dependent on flow profile and wave formation, and levels can be measured accurately and continuously over the entire pipe cross-sectional area.

Spitzer, who has since started his own company, Chesapeake Flow Solutions, stated that it is the location of the electrodes that creates the meter's distinctive capabilities.

"The electrodes are situated at about the 10% level in the diameter of the pipe," said Spitzer, whose new company represents KROHNE products. "So we're measuring down there, and there's also a capacitate level sensor inside the meter that actually measures the level of the pipe. The electrodes reveal the velocity of the liquid going through, and the level-element indicates how full the pipe is. That all gets integrated into a volumetric flow. It basically operates as a standard magmeter, but we relocate the electrodes toward the bottom and put a level measuring element behind the liner.

"This is kind of a unique configuration within the industry," he added. "There are a couple other manufacturers out there that try to measure partially full pipes; they use multiple electrodes around the pipe, so in between they're just estimating."

A welcome byproduct of the flowmeter's high measuring accuracy is low hydraulic losses and a low maintenance requirement. In addition, calibration of the meter in the field isn't necessary; continued accuracy is virtually assured with little or no involvement by operators or technicians.

Rambissoon says that the meter has not only performed just as expected, but presented few challenges during installation and setup.

"The entire setup and installation was extremely simple," he mentioned. "In fact, we didn't even need a factory person to come out and install it; we did it ourselves in house. And our operations people love it because it makes their job so much easier.

"But the most important benefit is the meter's functionality and accuracy. Most of the time we wouldn't be able to read a flow unless it was relatively high. Now we can get an accurate read at flow levels as low as 2 gallons per minute. Also, we can't overstate the benefit of being able to run the meter in automatic mode."

Spitzer went "the extra mile" to ensure that the device would continue to perform to Back River's standards.

"There were some questions about the additional wiring involved," he said. "Just to be certain that everyone was on the same page, I brought in a service guy and we did a mini-seminar at lunch time, because it was a pretty new device for them. I wanted Back River's in-house technicians to understand the nuances of the system and be able to address any potential problem, however unlikely, using internal resources."

Spitzer's extra effort seems to have won over even the harshest critics.

"There's one guy there who is skeptical of just about everybody's product," he said. "After we were able to get the measurement from that pipe for the first time ever, he actually shook his head and said, "It works.'"

Half full or half empty no longer matters to Back River. KROHNE has seen to that.

RICH LOWRIE is water and wastewater industry manager for KROHNE Inc. He can be reached at r.lowrie@krohne.com.

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