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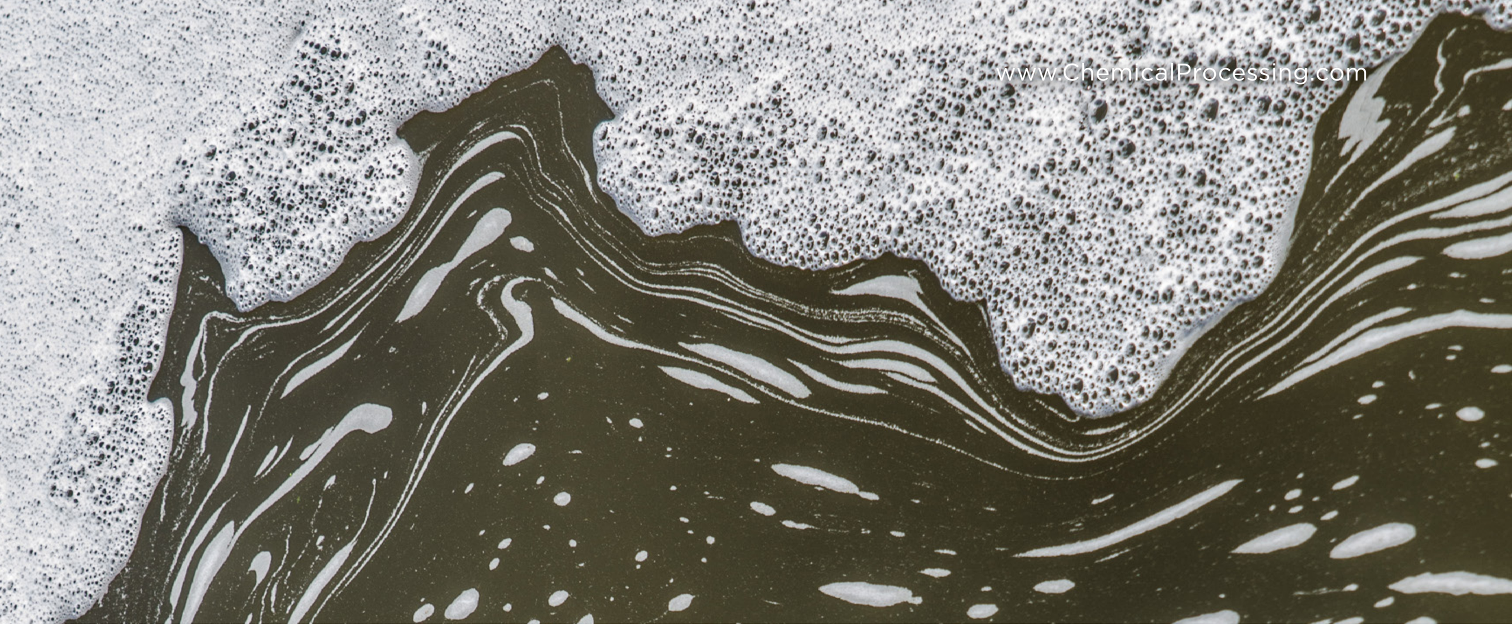

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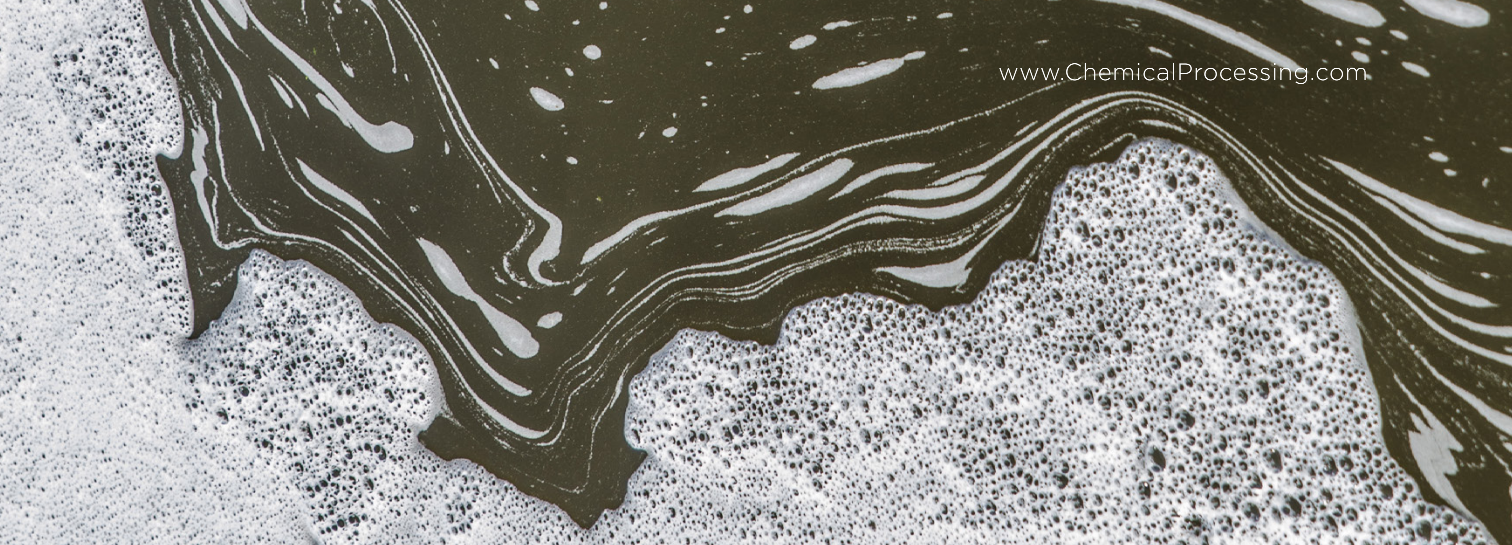

How To Succeed At Slurry Pumping

A variety of factors must be considered to ensure satisfactory service. Here are tips for selecting the right pump.

By Amin Almasi, mechanical consultant

Plants often must handle slurries in applications ranging from processing to wastewater treatment. Dealing with such mixtures of liquid and solids is challenging and difficult. Some key elements in slurry pumping are the size and nature of the solids in the liquid and the kind of the abrasive wear they cause. Another is the corrosiveness of the liquid or the mixture.

Sites frequently rely on centrifugal pumps for slurry services. These pumps (and their associated piping systems) need special provisions that call for a detailed knowledge of the solid and slurry properties to prevent wear, corrosion, erosion and other adverse effects such as settling of the solids. Specifying the optimum combination of speed, geometry and materials requires properly balancing often conflicting pump priorities; this demands consideration of stable operation, maximum wear life, operational flexibility and minimal energy consumption.

In this article, we'll cover practical guidelines and rules for centrifugal pumps for slurries. We'll also discuss key operational features, material selection and other considerations.

TAILORED PUMPS

Horizontal centrifugal pumps usually are used for slurry services, although vertical and other types of pumps are favored for some specific applications. Centrifugal pumps for handling slurries have features tailored to the particular service that reflect the corrosive or abrasive nature of the slurry and the solids concentration. These

Corrosion resistance is an important factor for material selection in many applications.

may include choice of materials, use of liners and even different driver sizing.

The first major requirement of a slurry pump is to provide adequate service life. Erosion and corrosion effects of slurries, such as the impingement of high velocity flow of liquid/solid mixtures, are really challenging. In many applications, some solids in the mixture are larger than usually specified particles; so, the pump should be able to pass them without any damage or operational problems.

As a result of such requirements, a slurry pump often is larger than its clear liquid counterpart. Moreover, it generally sacrifices efficiency, both maximum efficiency and efficiencies over the whole operating range, in exchange for the ability to achieve good operation in these challenging services.

Because wear is a function of velocity, a slurry pump's speed should be as low as possible; units usually operate at 1,200 rpm or slower. Often, direct coupling between the pump and a low-speed electric motor or other driver makes most sense. On the other hand, many other applications favor gearboxes to meet the desired speed and duty point. In services requiring variable flow, variable frequency drives are used to provide the necessary continual speed changes.

Although the emphasis on a slurry pump tends to be on the size and percentage of solids to be pumped, corrosion resistance is also an important factor for material selection in many applications. In such cases, the material chosen must provide an adequate combination of both erosion and corrosion resistance.

For slurry services, a pump operating on the left of the pump performance curve or at the best efficiency point (BEP) is usually preferred; as an indication, the rated point should lie somewhere between 85% and 100% of the BEP point.

The performance curves of many centrifugal pumps are based on handling water. So, to obtain the performance characteristics for these slurry centrifugal pumps, you must modify the results for the presence of solids. Many correlations and correction methods exist for predicting the performance of centrifugal pumps when handling slurries; these account for factors such as individual effects of particle size, particle size distribution, specific gravity and concentration of solids. They usually provide a head reduction factor and efficiency reduction factor for slurries compared to clear water. However, every pump has unique service-specific factors for a given application. You should verify these by experiments.

WEAR, EROSION AND CORROSION

Major factors that influence wear include the following:

- details of erosive particles (material, size, shape, etc.);
- concentration of solids;
- fluid velocity and particle velocity; and
- hydrodynamic properties of the flow (Reynolds number, etc.).

Turbulent flow analysis usually isn't applicable for slurry pumps because the presence of solid materials will directly influence the turbulence parameters. The mechanisms of turbulence become a complex problem particularly for dense slurries. This, combined with the nature of the flow inside a slurry pump, which is characterized by unsteadiness as well as deformed velocity distribution patterns, cause a very chaotic situation. However, some simple rules have been verified both in theory and experiments. For instance, the erosive wear rate is proportional to the flow velocity. It also depends on the solids concentration; as that concentration increases, so, too, does the wear rate. In addition, the sizing and specific gravity of solids in the slurry affect wear.

As a very rough indication, in medium and low concentrations, the mechanism of erosion resembles cavitation erosion. Here are some observations about a slurry pump that operated for a short period with low concentration slurry and then with a moderate concentration one. With the slurry at low concentration, the suction side of the blade showed very limited erosion at the leading edge while the rest of the surface was nearly unscathed. Most of the erosion of the back shroud was concentrated in the eye of the impeller and around the leading edge of the back-shroud corner. The maximum erosion appeared on the leading edge and towards the back shroud of the impeller. This pump, operated with a relatively higher concertation slurry, showed a similar erosion pattern — with the only notable difference being that the region close to the back shroud was more heavily eroded. Unfortunately, here and more generally, theoretical studies don't properly predict the level of erosion.

To cope with wear, pump designers generally rely on two options: use of thicker components or liners.

In the first approach, designers apply thickness allowances depending on estimates of erosion and corrosion of each part or component. Such pumps feature thick sections for all parts and components in contact with slurry including impeller and casing; those elements subject to high speed flow of slurry or solid impingements receive a greater thickness allowance.

Proper design and installation of liners can pose challenges.

In the second method, the designers provide wear liners on pump internals; many such pumps are fully lined internally. A lined pump, if properly done, can allow use of a wider variety of materials and also cost-effective application of exotic (expensive) materials. An unlined pump may offer lower initial capital cost. However, a properly lined pump usually affords a greater number of material choices, which may result in longer wear life and lower replacement spares cost. The lined pump also is inherently safer from a pressure containment standpoint because, in pumps relying on added thickness for components, corrosion and erosion over time might reduce the thickness to below the original value. Large clearances within the impeller and casing allow for the passage of large diameter solids, while also reducing internal velocities and corresponding wear. On the other hand, proper design and installation of liners can pose challenges — many pumps with liners have failed because of such inadequacies.

The materials used for wear components are hard metals, elastomers and, to a lesser extent, ceramics. Hard metals and ceramics combat erosion due to their high hardness values. Elastomers combat erosion by absorbing the energy of an impacting particle due to their resilience and tear resistance. Elastomers often can provide better erosion resistance in some applications. As a very rough indication, these are services where particle size is smaller than 250 microns, impeller tip speed is within the limits of the application of elastomers, and there's no risk of large particle damage. Elastomer-lined pumps have been successfully used in numerous slurry services.

Many metals have been used for slurry pumps. The ASTM A532 standard for abrasion-resistant cast irons covers the three basic types — "Martensitic White Irons" (Class I), "Chromium-Molybdenum White Irons" (Class II) and "High Chrome Irons" (Class III). These materials, which are made by melting processes, have been alloyed to achieve high resistance to abrasive wear. The bulk hardness of these alloys depends on many factors and parameters — for instance, not only upon the carbide and matrix type but also upon the volume of the carbides within the matrix. For slurry applications with small particles, microstructure, with smaller inter-carbide spacing, is particularly important to minimize erosion of the softer matrix. For slurry services with medium to large particles, the bulk (combined) material hardness is key. For applications with very large particles, fracture toughness of the matrix is important.

IMPELLERS

These tend to be larger than their clear liquid counterparts. Achieving a given head and providing more material for wear purposes requires a lower impeller speed. Minimizing speed and maximizing wear life of both the impeller and suction side depends upon a proper configuration.

High wear applications usually call for closed-type impellers. In applications with coarse particles, expelling vanes on the face of the front shroud make sense. These vanes prevent large particles from becoming trapped between the impeller and suction side liner and minimize recirculation. The benefit is reduced gouging and recirculation wear at the expense of a 2–3% drop in efficiency. In addition, expelling vanes often are used on the back shroud of the impeller in coarse particle applications to prevent the trapping of large particles between the impeller and back liner. In this location, they also serve to decrease the forward axial load by lowering the pressure acting on the back shroud and beneficially reducing the pressure at the hub. The decreased axial load improves bearing life. All these effects also cut the pressure differential at the shaft seal and reduce the tendency for slurry leakage from the pump. As with expelling vanes on the front shroud, back vanes usually absorb 2–3% of efficiency.

To combat wear and allow for passing large diameter solids, many slurry pump impellers feature fewer but thicker main pumping vanes. Both of these factors further contribute to reduced efficiency compared with clear liquid impellers. While a clear liquid impeller usually has five to nine vanes, most slurry pump impellers have two to five. Applications requiring large particle passing often employ pumps with two or three vanes. Slurry pumps use short blocky vanes in contrast to the thin long-length, long-wrap vanes found on high efficiency pumps for clear liquids.

SUMPS AND STORAGE TANKS

Slurry pumps usually require sumps or suction tanks to act as suction source or intermediate storage for slurries. However, lack of detailed knowledge about the slurry pump's behavior and sump hydraulics often leads to oversizing. The larger the sump or storage tank, the more likely it may become a settling tank for solids. For some services, the accumulation of solids leads to other problems, for instance, the build-up of harmful gases, and requires periodic desludging of the sump or tank, which increases operating costs and reduces overall safety and reliability. The optimal volume of suction storage, in this context, should prevent the settling of solids while avoiding problems for pump operation.

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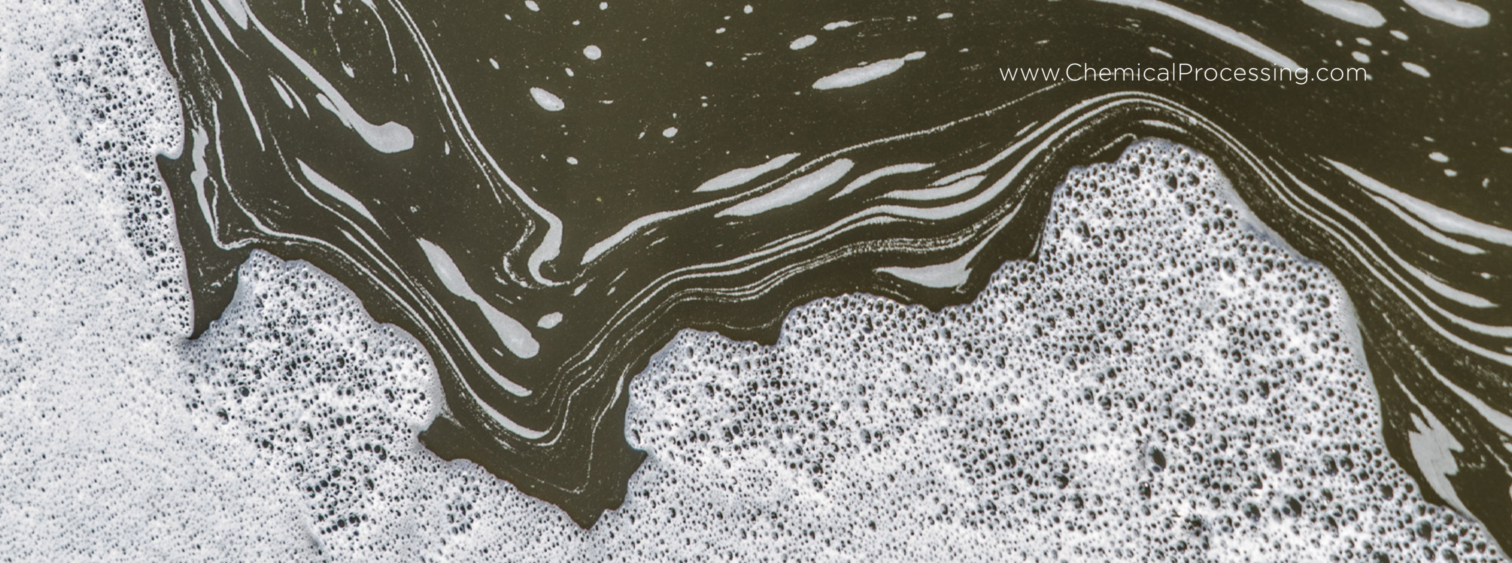


Consider Direct Steam Injection for Anaerobic Digestion Systems

Technology offers temperature stability and quick, even heating for wastewater treatment

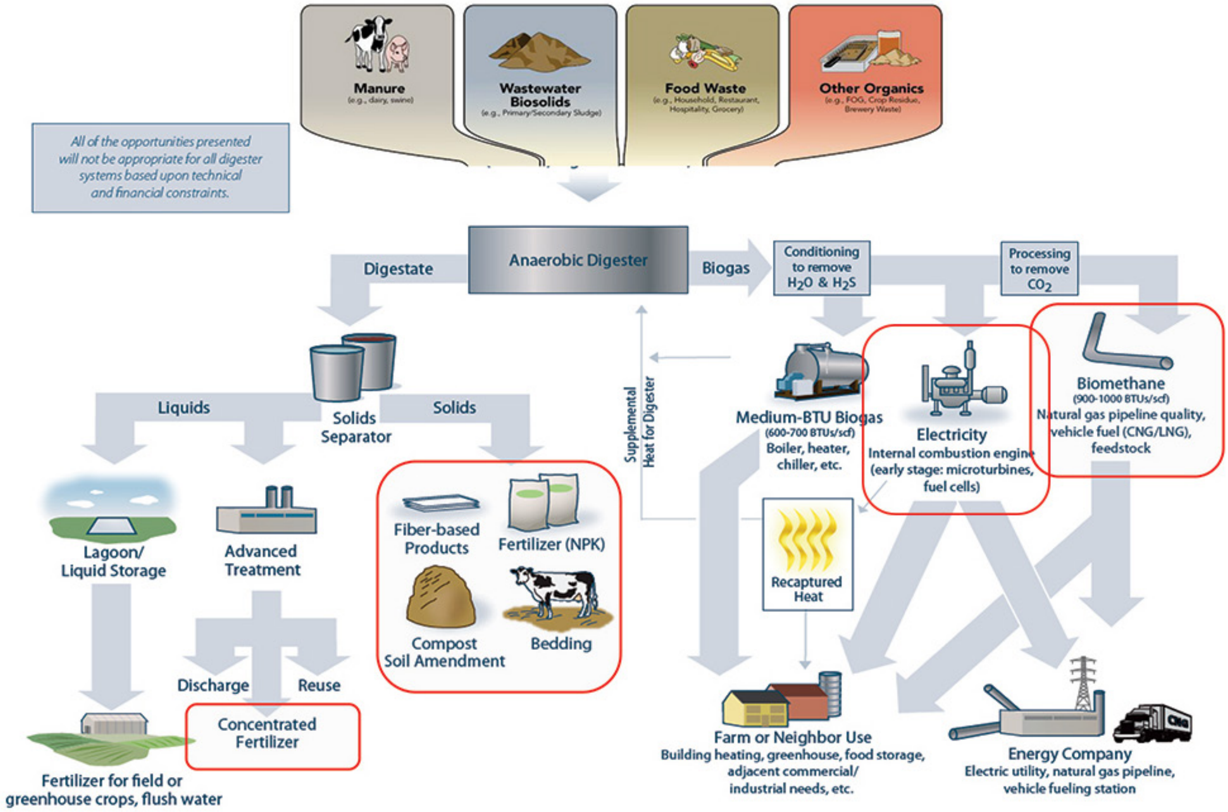
By Phil Hipol, Pick Heaters, Inc.

Many industrial processes generate organic wastes that require treatment before they can be reintroduced back into the environment. Traditionally, these materials have been buried in landfills, composted or deposited into sludge ponds after the removal of hazardous or inorganic materials. Another option is anaerobic digestion.

Anaerobic digestion involves the natural breakdown of organic waste materials by biological microorganisms in the absence of oxygen. Systems that incorporate anaerobic digestion have several advantages, such as simplicity of operation, low operating costs, compact equipment size and low surplus sludge. As a bonus, these systems produce fuel and energy.

Anaerobic digestion has become increasingly popular, as it is a green technology that reduces waste, generates energy, cuts carbon emissions and safely recycles waste materials back into the environment.

Anaerobic digestion systems operate on the same principles regardless of the application, although industry-specific requirements may necessitate slight differences in system design. As shown in Figure 1, organic waste materials, such as industrial wastewater, wastewater biosolids, food wastes and other organic materials, are placed into an anaerobic digester. The digester combines the waste materials with biological microorganisms and maintains this mixture within narrow temperature ranges to optimize bacteria



ANAEROBIC DIGESTER SYSTEM
Figure 1, The digester takes organic waste materials, combines them with biological microorganisms and converts them to digestate and biogas. ***Source: Environmental Protection Agency.***

growth, which is essential to the anaerobic digestion process.

Anaerobic digestion creates digestate (treated waste) and biogas. The digestate can be separated into solid and liquid components, which are rich in nutrients and can be composted; used as fertilizer; or converted into other products, such as dairy bedding or other fiber-based products.

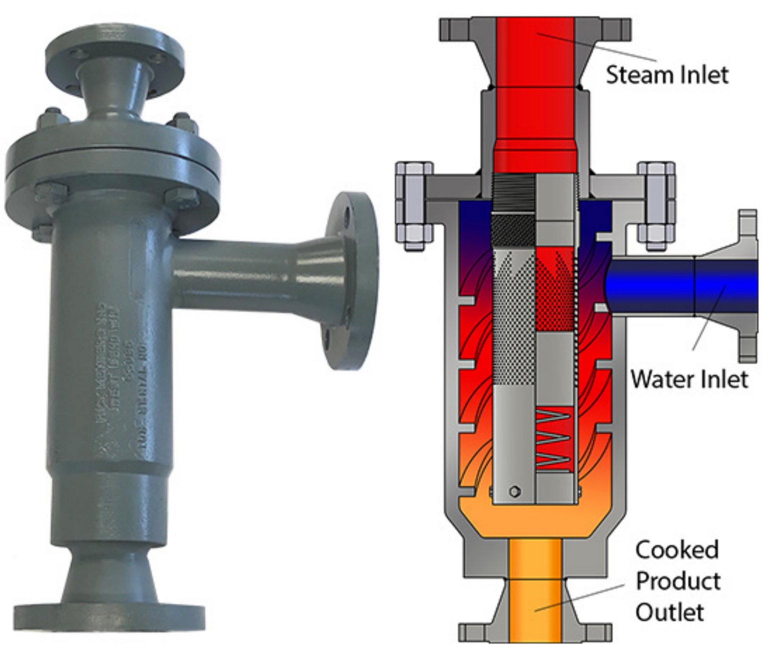
Meanwhile, biogas can be separated to extract methane, which is the primary component of natural gas. The methane can generate electricity or heat or be recycled back into the anaerobic digestion system. Methane also can be collected and processed into renewable natural gas and fuel, and it can be used locally or sold to energy providers.

The wastewater's temperature stability in the anaerobic digester is among the crucial parameters for effective digestion and biogas production. Conventional heat exchangers use a series of hot plates or tubes that contain heating elements or hot water. The waste material is heated in an indirect manner by passing or flowing across the conventional heat exchanger elements.

Because controlling the flow rate of high-viscosity fluids such as sludge is difficult, this process may result in uneven heating, which can compromise waste treatment or biogas production. System clogging may occur, causing burning or scorching of the waste material and requiring costly downtime for cleaning and maintenance.

IMPROVE EFFICIENCY WITH DSI

Direct steam injection (DSI) has been used for years in industrial chemical and pharmaceutical processing applications, such as biokill and sterilization, which require uniform processing temperatures. A DSI system can maintain temperatures rapidly and accurately for processing difficult materials, such as wastewater, and thereby increase the anaerobic digestion system's efficiency and reliability.



DIRECT STEAM INJECTION HEATER
Figure 2. Steam is injected directly into the untreated liquid slurry. The system's spring-loaded piston maintains a positive pressure differential between the steam and liquid. *Source: Pick Heaters.*

An example of a DSI heater is shown in Figure 2. The untreated and unheated liquid slurry enters from the side of the heater, and the injection tube injects steam into the slurry through hundreds of small orifices. Key aspects of this DSI system design include a spring-loaded piston that maintains a positive pressure differential between the steam and liquid, preventing steam hammer, and helical flights within the chamber that promote mixing of the steam with the slurry. These features heat the slurry instantaneously and evenly with an open flow-through nonclogging design while providing accurate temperature control.

PHIL HIPOL is a writer for Pick Heaters, Inc. For more information email info1@pickheaters.com.

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7.57
1056 mV
900

Measure Liquid Levels with Noninvasive Radar

Noncontact sensors provide reliable readings when a process connection isn't available

By Greg Tischler and Steve McCuskey, VEGA Americas

Many chemical plants and other industrial facilities have systems to clean and treat its water and wastewater. These water treatment facilities typically are separate from the main plant, and where untreated water undergoes a number of processes, including chemical treatments to clean the water before it is used in the plant or discharged back into a body of water or to the municipal water treatment plant.

Almost every industry views water treatment processes as a necessary expense that serves only to shrink the bottom line. To reduce costs, plants try to automate as many processes as possible. However, installing the wrong equipment can increase costs by increasing labor, maintenance and calibration expenditures. Fortunately, the latest radar sensors for liquid level measurement are simple and cost-effective (Figure 1).

Most industrial plants already are familiar with using radar technology for level measurement in other parts of the plant. The radar sensor sends a signal down into the vessel toward the medium being measured. The signal then is reflected back to the radar antennae, and the electronics within the sensor use the signal's time of flight to calculate a level. This is a simple noncontact level measurement solution. This measurement also can be noninvasive, without a need for a process connection or an opening in the vessel or tank.

MOUNTING ABOVE A TANK
Figure 1. This radar sensor is mounted above a plastic chemical tank to make a noninvasive, noncontact level measurement.

NONINVASIVE, NONCONTACT MEASUREMENT USING RADAR

Tanks store the chemicals necessary for the water treatment process. Accurate level measurement is critical for dosage control and inventory tracking. The chemicals used and how they're stored can vary from plant to plant, but plastic vessels often are used. These plastic tanks, or poly vessels, allow radar sensors to take a noninvasive, noncontact level measurement, regardless of chemical compatibility, and reduce the overall cost of installation.

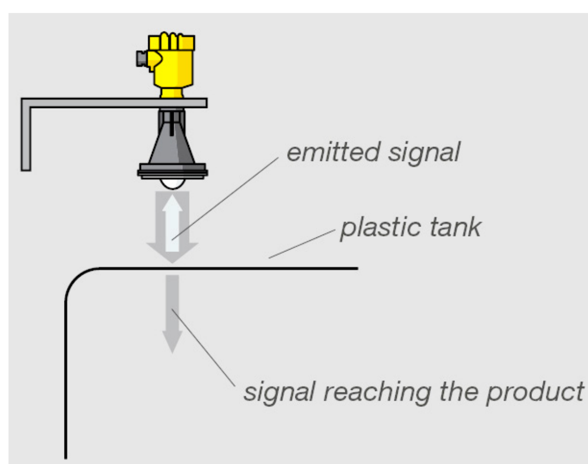
HOW IT WORKS

Radar signals can penetrate nonconductive products such as plastic and fiberglass, so a radar sensor mounted above a plastic vessel essentially will ignore the vessel structure all together. The initial radar signal is only partially reflected by the top of the vessel. The remaining signal passes through the vessel and reaches the product surface — a chemical used in the water treatment process in this case — with enough strength to be able to provide a reliable return signal and a subsequent level measurement (Figure 2).

Some radar sensors were designed with the water treatment industry and this type of application in mind. This type of radar can be installed above a chemical tank, and operators will get the accurate measurement they need — all the way to the top of the vessel — without requiring new or different process connections.

MOUNTING TIPS AND TRICKS

When mounting a radar above a plastic tank, installers should consider a few things



RADAR SIGNAL REACH
Figure 2. Enough of the radar signal reaches the product inside the plastic tank to provide a reliable and accurate level measurement.

to ensure accurate measurement. They need to be mindful of the vessel location and how the radar is mounted. Following a few best practices can deliver the best results.

Mounting a radar above a plastic tank should be done only indoors and away from the elements because rain, snow or other moisture on top of the vessel can reflect the radar signal and cause a measurement error. On the other hand, a little dust or dirt that accumulates on top of a vessel indoors won't interfere with the radar signal thanks to the sensor electronics (Figure 3).

The sensor should be placed between 4 and 8 in. above a curved portion of the tank or vessel. This additional space and curvature allow any minimal reflections from the vessel exterior to reflect laterally instead of returning directly to the antenna surface.

In the case of a tank or vessel with a flat top, this may not be possible, and additional adjustments may be needed. Finally, the sensor must be far enough from the sidewall because the sensor can detect any metallic objects outside of the vessel.

CONCLUSION

Measuring through plastic tanks provides an easy and accurate way to continuously track liquid levels of the chemicals used in industrial water treatment. The radar signal can penetrate the top of nonconductive plastic and fiberglass tanks, which minimizes installation costs when there is no existing available process connection.

INSTALLATION COST MINIMIZATION
Figure 3. Mounting the radar sensor above the plastic vessel minimizes installation costs.

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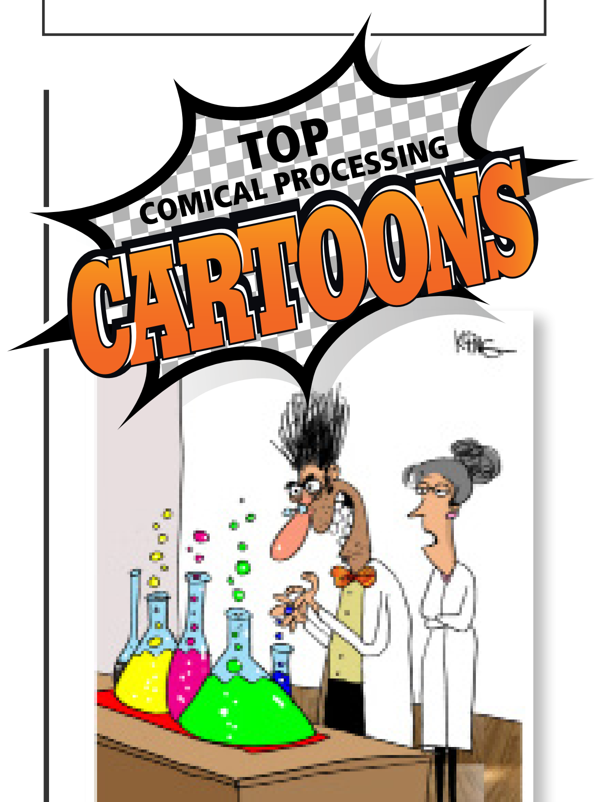

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