Overview

Automating the cleaning of tanks, totes, vats, vessels or any other type of container offers many benefits. Typically, the top reason to automate is to improve cleaning thoroughness. However, the reduction of maintenance time/production downtime is also a compelling and motivating factor. Other common reasons include improving worker safety, reducing consumption of expensive cleaning chemicals/solvents and lowering wastewater disposal costs.

Proper selection of a tank cleaning solution requires collaboration between process plant personnel and the tank wash equipment manufacturer. Cleaning objectives are specific to a manufacturing process and should be established by plant personnel. A variety of options are available — tank wash nozzles for clean-in-place (CIP), motorized tank washers, fluid-driven (turbine) tank cleaning machines and turnkey systems offering complete automation — and it is essential to consider your short- and long-term needs to ensure you make the right buying decision.

The discussion within addresses the following:

Cleaning Criteria
- What is the residue to be cleaned?
- What cleaning is required to remove the residue?
- What is the temperature of the cleaning liquid?
- What is the reason for cleaning?
- What level of cleaning is required?
- What flow design is used?
- What are the dimensions of the tank?
- Are there obstructions within the tank?
- How many tanks need to be cleaned?
- How often do they need to be cleaned?
- What is the size of the porthole and where is it located?
- What equipment is available?

Understanding the Available Options
Spray technology fundamentals and effect on cleaning efficiency:
- Flow design
- Flow rate
- Spray pattern
- Spray coverage
- Shadowing
- Spray distance
- Spray impact
- Cycle time

Understanding Possible Solutions
- Clean-In-Place (CIP) nozzles/systems
- CIP or portable motorized and fluid-driven (turbine) tank washers
- Automated tank cleaning systems

Final Product Selection
- Identifying the option that best meets cleaning objectives
- Determining materials of construction
- Installation considerations: CIP, portable, physical layout
Introduction

Process improvement and cost reduction are key motivators for any plant. As a result, automated tank cleaning is increasing in popularity. A change in tank cleaning methods can result in dramatic increases in production uptime, a reduction in the amount of labor required for cleaning and cost savings on water, cleaning chemicals, energy and wastewater disposal. There are other benefits as well — improved worker safety and elimination of the need for Vessel Entry Permits required by OSHA.

Nearly all totes, tanks, vessels and vats contain product residue that must be removed between batches or at routine intervals in continuous operations.

Historically, two methods have been used for tank cleaning:

1 The Manual Method
   A worker physically cleans a tank and may actually enter the tank. This raises safety concerns about tank entry/exit and exposure to toxic fumes from cleaning agents. The Manual Method often results in inconsistent cleaning and the use of more cleaning chemicals and water than is really necessary.

2 The Fill and Drain Method
   Tanks are usually hosed down and then filled with hot water or a mix of water and cleaning/sanitizing agents. The tank may be drained and rinsed several times before use. This method is time-consuming and utilizes significant amounts of water, cleaning chemicals and energy. It also can keep a tank out of production for several hours.

Many plants find they can save tens of thousands of dollars annually by automating their tank cleaning process. Facilities with several tanks have reported savings of more than $100,000 per year. Determining if you could benefit similarly through automation begins with a close look at your cleaning objectives.

Establishing Cleaning Objectives

The primary objective of any tank cleaning project is to clean, maintain and sanitize equipment at appropriate levels to prevent malfunctions or contamination that would alter the safety, identity, strength, quality or purity of the finished product. Each tank cleaning application is unique and finding the best automated solution requires a collaborative effort between process plant personnel and the tank wash equipment manufacturer.

The first step in setting objectives requires an evaluation of the product residue to be cleaned.

A product residue is defined as any material left behind which should be washed away before another batch of product arrives.

<table>
<thead>
<tr>
<th>Residue can come in different forms</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Residue that does not stick to the surface and can therefore be cleaned easily</td>
</tr>
<tr>
<td>• Residue that does not wash away quickly but can be dissolved by the cleaning liquid</td>
</tr>
<tr>
<td>• Residue that does not dissolve by the cleaning liquid but relies heavily on the spray impact to break it up and wash it away</td>
</tr>
</tbody>
</table>

The second step is to identify a cleaning liquid.

The cleaning liquid will react with the product residue to physically wash it away or dissolve it. Once you’ve identified the cleaning liquid, you need to consider its temperature and material compatibility. This will be important when selecting the tank wash nozzles/system for your application.

The third step is to determine what level of cleaning is required:

<table>
<thead>
<tr>
<th>What level of cleaning is required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rinsing</td>
</tr>
<tr>
<td>Cleaning</td>
</tr>
<tr>
<td>Sanitizing</td>
</tr>
<tr>
<td>Disinfecting</td>
</tr>
<tr>
<td>Sterilizing</td>
</tr>
</tbody>
</table>

Once you’ve established your cleaning objectives — what you need to clean, what you are going to use to clean it and the required cleaning level — it is time to focus on tank washing technology so you understand how to evaluate your options.
**Automated Tank Washing: Spray Technology Fundamentals**

**Flow Design**

There are two forms of system flow design:

1. **Total loss flow design**
   - is when the cleaning liquid is used once and then discharged. This design is only applicable when cleaning is infrequent or very small volumes of liquid are needed. Total loss flow design is advantageous because it prevents cross contamination from cleaning liquids.

2. **Partial or total recovery flow design**
   - is when the final rinse liquid is recovered and a water make-up rate is determined for reuse. A recirculated cleaning system will be more contaminated than the total loss flow design. However, a partial or total recovery flow system uses less chemicals and water than a total loss flow system. The water supply needs to be evaluated for any potential problems, such as dissolved solids or suspended particulate, which may interfere with the cleaning process. Use the appropriate strainer and mesh.

**Flow Rate**

Use the lowest flow rate possible to achieve your cleaning objectives. The lower the flow, the less liquid required, less effluent for disposal and less energy consumed.

If you’re not sure how much flow is required, a general guideline is to work with a minimum of 0.2 gal/min/ft² (7 l/min/m²) of vessel internal surface area. A more moderate recommendation is 0.4 gal/min/ft² (15 l/min/m²). This guideline applies generally to stationary nozzles where all the surfaces of the tank are sprayed at the same time. Nozzles that rotate usually contact part of the tank at one time. Less flow rate is needed. Refer to published tank diameters and testing to determine the correct flow rate for rotating nozzles.

**Spray Pattern**

Most spray balls and tank wash nozzles generate a solid stream, flat fan or full cone spray. Your cleaning requirements will determine the pattern you need. In general, under equal operating conditions, solid stream sprays provide the greatest impact, followed by flat fan and full cone sprays.

Typically, fixed spray nozzles with full cone sprays are used for gentle rinsing and washing. Fluid-driven nozzles with flat fan sprays offer more impact and are commonly used for cleaning. High-pressure motor-driven and fluid-driven (turbine) nozzles use solid streams for maximum impact.

**Spray Coverage**

Typical coverages include 180° up, 180° down, 270° up, 270° down and 360°. Again, you want to use the least amount of coverage required to achieve your cleaning objectives and eliminate unnecessary water usage and wastewater disposal.

<table>
<thead>
<tr>
<th>Spray Coverage</th>
<th>180° up</th>
<th>180° down</th>
<th>270° up</th>
<th>270° down</th>
<th>360°</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image_url" alt="180° up" /></td>
<td><img src="image_url" alt="180° down" /></td>
<td><img src="image_url" alt="270° up" /></td>
<td><img src="image_url" alt="270° down" /></td>
<td><img src="image_url" alt="360°" /></td>
</tr>
</tbody>
</table>
Automated Tank Washing: Spray Technology Fundamentals

Shadowing
When a spray cannot directly reach part of the vessel because of an internal obstruction, it is called shadowing. This obstruction can be a mixer, agitator or filling tube for example. The problem is to clean both the shadowed area and the obstruction itself. In cases where one nozzle cannot cover the entire internal surface, multiple nozzles are used.

Spray Distance
Spray distance, sometimes referred to as “throw”, is defined as the distance between the spray exiting the nozzle orifice to the spray hitting the target surface. The spray coming from the nozzle should extend to reach the walls of the tank vessel. Just because the spray reaches the tank surface, does not mean it can clean the heavily soiled areas. The spray loses impact the farther away it gets from the nozzle. Adequate pressure should be supplied to the nozzle so the cleaning liquid will be sprayed with enough impact and spray distance. Most nozzle manufacturers will specify the diameter of a tank vessel that the spray will reach to effectively clean the tank internal surface. However, it is important to take the tank length into account as well. If you have a tank that has a 20’ (6 m) diameter and 40’ (12 m) length, you should not use a tank washer that only specifies a tank diameter of 20’ (6 m). You will need to use two tank washers that specify 20’ (6 m) or a different tank washer that can clean up to 40’ (12 m).

Spray Impact
How much impact is required depends on a variety of factors — the residue, the cleaning chemicals, the water temperature and more. Hard-to-clean residues require a higher level of impact than residues that are easily rinsed. The theoretical spray impact can be obtained from the following equation:

\[ I = K \times Q \times \sqrt{P} \]

where

- \( I \): Total theoretical spray impact
- \( K \): Constant
- \( Q \): Flow rate
- \( P \): Liquid pressure

For any given nozzle, this is the total impact, neglecting all losses that an equivalent solid stream nozzle would have when operating at the same pressure and with the same flow as the given nozzle.

Effects of flow rate on impact:
Using the equation above, it can be concluded that increasing flow rate is more effective than increasing pressure. As the table below shows, doubling the flow rate increases impact as much as 100%, while doubling pressure provides only 40% more impact.

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>Pressure</th>
<th>Relative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 gpm (50 l/min)</td>
<td>45 psi (3 bar)</td>
<td>1.0</td>
</tr>
<tr>
<td>13 gpm (50 l/min)</td>
<td>90 psi (6 bar)</td>
<td>1.4</td>
</tr>
<tr>
<td>26 gpm (100 l/min)</td>
<td>45 psi (3 bar)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Effects of spray pattern and spray angle on impact:
Spray pattern and spray angle affect impact efficiency. In general, solid streams with a 0˚ spray angle provide the greatest impact of all other patterns since force is directed over a smaller area.

The table below shows the Total Impact Efficiencies and is defined as:

\[ \text{Total Impact % Efficiency} = \frac{\text{Actual Total Impact}}{\text{Theoretical Total Impact}} \]

<table>
<thead>
<tr>
<th>Spray Pattern Type</th>
<th>Nozzle Spray Angle (˚)</th>
<th>Total Impact Efficiency 12&quot; (30 cm) from Spray Nozzle (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Stream</td>
<td>0</td>
<td>99 to 96</td>
</tr>
<tr>
<td>Flat Spray</td>
<td>15, 25, 40, 50, 65, 80</td>
<td>95 to 90</td>
</tr>
<tr>
<td>Full-cone Spray</td>
<td>15, 30, 50, 65, 80, 100</td>
<td>85 to 81</td>
</tr>
</tbody>
</table>
Automated Tank Washing: Spray Technology Fundamentals

Spray Impact

**Effects of spray distance on impact:**
The actual impact of a solid stream nozzle is close to theoretical when 12” (30 cm) away from the nozzle. The further the spray is from the nozzle, the impact efficiency lessens. Below is an example of the impact values taken at various distances for a solid stream nozzle:

<table>
<thead>
<tr>
<th>Radial Distance</th>
<th>Impact Force for a Single Orifice (lb on one foot square target)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ft. 0 Meters</td>
<td>0.00 0.0 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0</td>
</tr>
<tr>
<td>0.6 1.2 1.8 2.4 3.0 3.6 4.2 4.8</td>
<td></td>
</tr>
</tbody>
</table>

Data showing the decrease in impact as distance is increased from the nozzle’s orifice should be available from the manufacturer.

**Effects of pressure on impact:**
Consider operating at the lowest possible pressure to handle your specific cleaning requirements. If more impact is required, consider increasing flow rate instead of pressure to get twice the impact. Increasing pressure may actually decrease impact as the spray will start to atomize into smaller droplets and lose its cleaning effectiveness.

**Effects of rotational speed on impact:**
When increasing pressure to achieve faster cleaning cycle times, be aware that faster rotational speed can compromise cleaning impact and efficiency. The spray rotates so fast that energy dissipates as the spray is no longer a controlled pattern when it hits the tank surface. The spray needs solid contact with the tank surface with enough time to clean the residue.

Cleaning Cycle Time

There are four common cleaning stages. In many cases, if cleaning effectiveness falls short, more thorough cleaning can be achieved by extending the time of one or more stages.

<table>
<thead>
<tr>
<th>What level of cleaning is required</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Rinse</strong></td>
<td>This stage typically removes 90% of the residue.</td>
</tr>
<tr>
<td><strong>Cleaning</strong></td>
<td>This stage involves the application of the chemical. Using cleaning detergents will chemically remove contamination or surface film, working with the soil over a period of time. Consulting a chemical supplier will help you determine the optimal chemical residence time for your process. With water-based chemicals, increasing temperature will also improve cleaning action. However, heating the cleaning liquid can be expensive. If the vessel can be cleaned at room temperature, then it is worth considering.</td>
</tr>
<tr>
<td><strong>Post-Rinse</strong></td>
<td>During this stage, suspended residue and cleaning agents are removed. Rinse time will be determined by the absence of residue.</td>
</tr>
<tr>
<td><strong>Sanitizing</strong></td>
<td>If required, the chemical manufacturer will provide instruction for the cycle time.</td>
</tr>
</tbody>
</table>

Depending on the application, cleaning can be done in as little as a minute or take up to 45 minutes or more. Most cleaning cycles fall within the 10 to 30 minute range.
A Guide to Tank Cleaning Automation

Automated Tank Wash Product Options

**Clean-In-Place (CIP) Nozzles/Systems**

CIP systems usually consist of spray balls or spray nozzles permanently mounted on pipes over a tank. They usually operate at low pressures and offer economical and reliable performance.

CIP systems can be configured with a wide variety of spray balls or nozzles, so it is important to understand the various operating methods and resulting performance.

The chart below provides an overview of nozzles typically used in CIP applications.

<table>
<thead>
<tr>
<th>Nozzle Type</th>
<th>Description</th>
<th>Common Applications</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed (Stationary)</td>
<td>Nozzles stay in position while spraying</td>
<td>Rinsing or gentle cleaning of tanks ranging in size from 2’ to 15’ (0.6 m to 4.5 m)</td>
<td>Simple design, no moving parts, wide range of spray coverages, no mounting limitations</td>
<td>Low impact, small free passage which can result in clogging, high liquid usage</td>
</tr>
<tr>
<td></td>
<td>Classic spray ball with holes around it</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multiple nozzle assembly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluid-Driven Reactionary Force</td>
<td>Nozzles are free spinning, increasing rotational velocity as pressure to the nozzle increases</td>
<td>Rinsing and cleaning of tanks 3’ to 18’ (0.9 m to 5.5 m) with a choice of solid stream or flat fan spray patterns</td>
<td>Higher impact, good overall coverage, reduced fluid requirements</td>
<td>As speed increases, the spray decreases in focus; Clogging could prevent rotation especially if water supply isn’t clean</td>
</tr>
<tr>
<td>Fluid-Driven Constant Speed</td>
<td>Nozzles use the momentum of the liquid flow to drive the nozzle’s spray head while constant rotating speed is maintained. Fluid pressure can be adjusted independently providing adjustments in impact force.</td>
<td>Cleaning and sanitizing of tanks 13’ to 20’ (4 m to 6 m)</td>
<td>The slow rotational speed improves impact and throw compared to reactionary force nozzles</td>
<td>Good filtration is needed to keep contaminating particles away from the gears so that rotation won’t be blocked.</td>
</tr>
</tbody>
</table>

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Automated Tank Wash Product Options

CIP or Portable Motorized and Fluid-Driven (Turbine) Tank Washers

Other options are high-pressure motor-driven tank washers and fluid-driven (turbine) tank washers. These units are typically used to clean tanks ranging in size from 8’ to 86’ (2.4 m to 26 m) in diameter that require more thorough cleaning.

Motor-driven tank washers use solid stream nozzles and operate at pressures from 100 to 1000 psi (6.9 to 69 bar) to remove stubborn residue. The motor, air or electric, drives the nozzle assembly. Two to four nozzles revolve around the central axis of the nozzle assembly. Motor-driven tank washers offer independent control of the liquid pressure for cleaning and the rotational speed (cycle time) to optimize the cleaning process.

Fluid-driven (Turbine) Tank Washers utilize the fluid to spin the turbine. The turbine in turn powers a gear set. The nozzle assembly rotates as the hub revolves around its central axis. These units offer high impact cleaning and are typically used in large vessels or tank cars.

These motorized and fluid-driven (turbine) tank washers can be taken from tank to tank or permanently installed. The distance between tanks, cleaning cycle frequency, the number of tanks, the flow system design and labor availability are key considerations when choosing between portability and permanency.

A review of the advantages and disadvantages of motorized and fluid-driven (turbine) tank washers will help you determine whether they offer the proper level of automation and cleaning.

Automated Tank Cleaning Systems

The next level in automated tank cleaning is a turnkey system that offers precise control of the tank wash nozzles and eliminates the need for operator intervention.

Fully automated systems optimize the performance of spray nozzles and motorized tank washers. Available for a wide variety of flow rates and operating pressures, turnkey systems include a control panel, pumps and valves bundled into an efficient package. Some of these systems can be placed on mobility casters for system portability.

Automated tank cleaning systems offer many benefits:

- Standard pump/motor sets are sized for best operating efficiency and optimal performance of tank cleaning nozzles.
- Repeatable tank cleaning performance that facilitates regulatory compliance and ensures operator safety.
- Precise control of cycle times ensures cleaning objectives are achieved in the shortest cycle time, conserving energy and water.
- Push button system management. Cleaning cycles and multiple cleaning routines can be adjusted and activated quickly and easily. Labor requirements for system set-up, operation and maintenance are minimal.
- Automated chemical injection. The correct amount of chemical is injected consistently, ensuring cleaning effectiveness and preventing waste of costly chemicals.
Maintenance and Safety Considerations

Be sure to establish a regular cleaning schedule to avoid problems. Use filters and strainers to minimize clogging and clean them as needed. It is helpful to document your maintenance procedures to ensure consistency and help troubleshoot problems should they occur.

You may also need to take steps to prevent static in environments where the possibility of explosion exists. Grounding, using conductive wash, eliminating oxygen prior to washing, charging the vessel with nitrogen and choosing spray nozzles that can be used in explosion proof environments are all options to consider. Some tank wash nozzles are ATEX certified which fulfill the European EC-Directive 94/9/EC “Equipment and protective systems for use in potentially explosive atmospheres”.

Cleaning Validation Options

Once you’ve selected and installed your automated solution for tank cleaning, you’ll need to validate that it is doing its job.

The most common technique is to visually inspect the system to see if tanks appear clean, confirm spray balls and tank wash nozzles are not clogged and confirm reactionary-type nozzles are spinning freely. If your tanks are large, the inside of the tank may not be visible. Mounting a pressure sensor to the inside of the tank wall is a widely-used solution. The sensor will measure the changes in pressure on the wall surface as the spray rotates and verify the spray head is turning appropriately.

In other applications, validation is often done by coating tanks with proteins or other substances that fluoresce under UV light. Riboflavin is often used because it is water-soluble. It is sprayed onto all contact surfaces of the tanks including areas shadowed by obstructions as well as the obstruction. A cleaning cycle is run and upon completion, the tank is inspected with a UV light. If there is no evidence of fluorescence, the performance of the CIP system has been validated.

Other validation techniques include taking cultures with swabs to verify the desired level of disinfection has been achieved. Also, measuring the conductivity or resistivity of the water or the cleaning agent will determine if contamination is present.

To confirm internal surfaces are clean, the final tank wash effluent can be analyzed for contamination. Analysis of the process product batch immediately following cleaning can provide a final check.

Customized validation protocols may be required for some applications. Manufacturers of tank cleaning systems should be able to assist with automating protocols and documentation.

Automation Pays Off Quickly

Automation results in cleaner tanks, repeatable cleaning, decreased risk of product contamination and reduced cost of consumables. But, at what cost?

Automation is often associated with the words “expensive” and “costly.” However, low-pressure CIP systems are quite economical since the cost of spray balls and nozzles is very reasonable. Motorized tank washers and automated tank cleaning systems are more costly but typically offer a quick return on investment. Many users of automated tank cleaning products and systems report a payback period of just a few months. The gain in production uptime and the reduced labor cost comprise most of the savings. The reduced cost of chemicals, water, energy and wastewater disposal also add up quickly and contribute to the short payback period.

Is automated tank cleaning for every manufacturer? In most instances the answer is yes. However, it is important to thoroughly research all the automation options available to ensure you will achieve your tank cleaning objectives as efficiently and economically as possible.

Payback Calculation Example

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ The cost to clean these tanks manually $40,560 (US) annually</td>
<td>✓ An annual savings of $38,168 (US)</td>
</tr>
<tr>
<td>✓ The cost to clean these tanks using an automated tank washer $2,392 (US) annually</td>
<td></td>
</tr>
</tbody>
</table>

This example is based on using a motorized tank washer. The savings acquired during the first six to seven weeks of operation will offset the cost of the unit.
## Selecting the Right Tank Cleaning Products

If you believe you can benefit from automated tank cleaning, the next step is to identify the exact products required. The checklist below may prove helpful.

In choosing an automated tank wash solution, be sure to select a company that is willing to work with you. A broad product line, a proven track record and references are essential. Ask about access to application specialists to ensure problem solving assistance will be available if needed. It is also a good idea to request maintenance recommendations early in the process, so you know how much time to allocate and what type of future financial investments may be required.

### Automated Tank Cleaning Checklist

<table>
<thead>
<tr>
<th>Task</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compile all the vital statistics about your tank cleaning needs</td>
<td>• Residue type&lt;br&gt;• Chemicals required for cleaning&lt;br&gt;• Temperature of cleaning liquid and material compatibility&lt;br&gt;• Temperature of tank&lt;br&gt;• Cleaning level required</td>
</tr>
<tr>
<td>Compile all the relevant information about your application</td>
<td>• Existing cleaning methods&lt;br&gt;• Tank size&lt;br&gt;• Number of tanks&lt;br&gt;• Tank port size and location&lt;br&gt;• Physical location of the tank&lt;br&gt;• Existing flow design and equipment&lt;br&gt;• Water quality&lt;br&gt;• Filtration needs&lt;br&gt;• Special requirements such as materials of construction&lt;br&gt;• Validation and documentation needs</td>
</tr>
<tr>
<td>Conduct some preliminary research</td>
<td>• Ask your colleagues about their tank cleaning applications&lt;br&gt;• Talk to your nozzle supplier or identify companies that sell automated tank cleaning equipment</td>
</tr>
<tr>
<td>Identify two to three suppliers of tank cleaning equipment and request a no-obligation on-site evaluation</td>
<td>• Schedule a meeting to exchange information and view tanks&lt;br&gt;• Request a proposal and payback analysis&lt;br&gt;• Ask if they have a demonstration/trial program so you can “try before you buy”</td>
</tr>
</tbody>
</table>

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Typical Automated Tank Wash Applications

- **Fixed spray balls** provide low-pressure washing and rinsing of chemical and pharmaceutical tanks.
- **Motor-driven tank washers** add liquid to a batch in a reactor vessel and then provide complete rinsing when the reaction is complete.
- **Keg washing nozzles** remove tobacco particles in duct washing operation.
- **Fluid-driven tank wash nozzles** clean liquid and pigment from broke chest ceilings.
- **Milk filling machines** are cleaned by fluid-driven tank wash nozzles.
- **Fluid-driven constant speed tank wash nozzles** rinse the interiors of food mixing tanks.
- **Compact keg washing nozzles** clean and sterilize kidney dialysis barrels.
- **Fluid-driven constant speed tank wash nozzles** clean the large tanks used in cellulose manufacturing.
About the Author

Christine Pagcatipunan is an applications engineer at Spraying Systems Co. As the company’s tank cleaning expert, she analyzes and customizes automated tank cleaning solutions for customers in a wide range of industries. Pagcatipunan is an experienced author and speaker. She earned a bachelor’s degree in chemical engineering from Illinois Institute of Technology (IIT) and a master’s degree in marketing communications from the IIT Stuart Graduate School of Business.

About Spraying Systems Co.

Spraying Systems Co. is the leader in spray technology with the most extensive product line, global manufacturing and sales offices in more than 85 countries. Spray nozzles, turnkey spray systems, custom fabrication and research/testing services comprise the company’s offering.