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Effectively Clean Tanks and Reactors

Choose the right equipment to avoid costly contamination problems

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TANKS, REACTORS and other vessels can be cleaned in many ways. However, use of automated clean-in-place systems has increased rapidly. That's because automated devices clean more thoroughly than other methods, dramatically reducing or eliminating risk of cross-contamination caused by product or cleaning-chemical residue.

Automated cleaning provides other benefits as well:

• faster return to service of vessels — downtime can be reduced by as much as 90%;

• decreased water and chemical use;

• lowered wastewater disposal costs;

• improved safety because workers no longer have to enter tanks; and

• better staff productivity because people can be deployed to other tasks.

The decision to automate is easy — a plant usually can recoup the cost of an automated system in the first few months of operation through reduced chemical and water costs and increased production. However, determining the best cleaning equipment can be hard. If vessels are large, have obstructions such as mixing paddles, and contain sticky, flammable or toxic residues, selection can get challenging. So, this article offers some guidelines to help you choose the most appropriate equipment for your operation.

THE STARTING POINT

Before you begin evaluating cleaning equipment, you must understand your cleaning requirements.

Residue. First, assess the residue to determine what's required to remove it. Is the substance sticky or easily cleaned? Can a cleaning liquid dissolve it? If not, what level of impact is needed to break it up and wash it away?

(If you're not sure how to remove the residue, a cleaning equipment vendor can use computational fluid dynamics modeling to determine the flow rate, operating pressure, coverage and the position of the spray head for complete cleaning of the vessel and any permanently installed equipment.)

Cleaning agents. Once you understand the residue's characteristics, you can sort out which cleaning agents to use. Chemical additives typically are employed to remove contaminants, improve tank wetability and reduce foam. Heat can boost the cleaning action of many water-based detergent chemicals.

Vessel size. Interior surface area and distance between the walls substantially affect selection. Evaluate the spray distance, usually measured in terms of the vessel diameter, but also consider vessel length and height. For example, for a 20-ft.-dia., 40-ft.-long vessel, use two vessel cleaners that each can handle up to 20 ft. or a single vessel cleaner that can handle up to 40 ft. You many need multiple nozzles if the spray can't reach a part of the vessel due to internal obstructions such as an agitator (Figure 1).

Impact. The level of impact needed to thoroughly clean vessels depends on the residue, cleaning chemicals and water temperature. Hard-to-clean residues require greater impact. The theoretical spray impact, I, equals $K\,Q\,P^{1/2}$ where K is a constant, Q is flow rate and P is liquid pressure.

If you're not certain how much impact is needed, a cleaning equipment vendor should be able to provide guidance and impact data. Some manufacturers will conduct tests in their spray labs with your specific residue to optimize

OPTIMIZE CLEANING

Six steps may provide significant benefits:

1. Reduce use of heated water. Hot water is costly but frequently is viewed as a necessary evil to remove some residues. However, increasing impact often can often get the job done and cut or eliminate the need for hot water.

2. Minimize "striping." Vessel cleaners provide 360° coverage. However, the solid stream sprays don't overlap as they rotate, so there's a small distance between the sprays and thus a so-called striping effect. The greater the distance the nozzles are from the vessel walls, the greater the distance between the sprays. The best way to minimize striping is to use a four-nozzle hub rather than the standard two-nozzle hub. This will cut striping in half.

3. Change spray head position. Use an adjustable ball fitting to clean vessels in sections. Clean the top half of the vessel, then lower the device and clean the bottom half of the vessel or change the angle to clean difficult locations.

4. Decrease the number of cleaning cycles. Simple adjustments to pressure and flow may enable a reduction in the number of cycles needed for thorough cleaning. To increase impact and cleaning efficiency it's far more effective to increase flow than pressure. Doubling flow rate boosts impact as much as 100%; doubling pressure only provides 40% more impact.

5. Recirculate. Do you spray and drain? Check into recycling your cleaning solution if you aren't using hazardous materials and your water is debris free.

6. Activate cleaning with the flip of a switch. Hard piping your vessel cleaner in place can save time and reduce labor costs. Consider permanently installing the device if the material or its temperature won't damage the cleaning equipment.

cleaning performance. Another option is a short-term lease on a pumping system and vessel cleaner, so you can evaluate the equipment in your production environment. Some vendors also offer no-obligation equipment trials.

Safety. Is the residue, cleaning solvent or environment toxic or flammable? The answer will significantly influence the type of equipment you choose.

Once you understand your cleaning requirements, the next step is to evaluate the cleaning equipment. So, let's look at what's available and the pros and cons of each option.

THE TYPE OF POWER

The first decision is whether to use a machine powered by fluid or a motor.

• Fluid-driven cleaning machines use fluid to spin a turbine that powers a gear set (Figure 2). The nozzle assembly rotates as the hub revolves around its central axis. The higher the liquid pressure and flow, the faster the rotation.

• Motor-driven cleaning machines rely on an external electric or air motor to drive the nozzle assembly (Figure 3). The nozzles revolve around the central axis of the nozzle assembly.

Both machines operate at high pressures, provide 360° cleaning coverage and suit large vessels (up to 100 ft. dia.). They often offer comparable cleaning performance. However, there are several operational differences.

Clogging. A fluid-driven machine is more prone to clogging. As fluid passes through the device, debris can accumulate in the internal flow passages or get caught in the gears. When this happens, the machine stops working because the gears no longer can rotate. Verifying operation is crucial but can be challenging — it's difficult to visually observe the inside of a large vessel.

A motor-driven machine will continue to operate even with debris in the nozzles. The external motor ensures continued rotation and cleaning. Plus, you easily can hear the sound from the motor and verify operation without having to inspect the vessel.

If you're using less than pristine water and it's difficult to see inside your vessel, a motor-driven machine is a better choice.

Cleaning cycle time. If short cleaning cycles are a priority, consider a motor-driven unit. Using an electric motor, cycle times remain constant regardless of operating pressure and flow rate. With an air motor, you can increase air pressure to make the nozzle hub rotate more quickly.

Multiple Nozzles

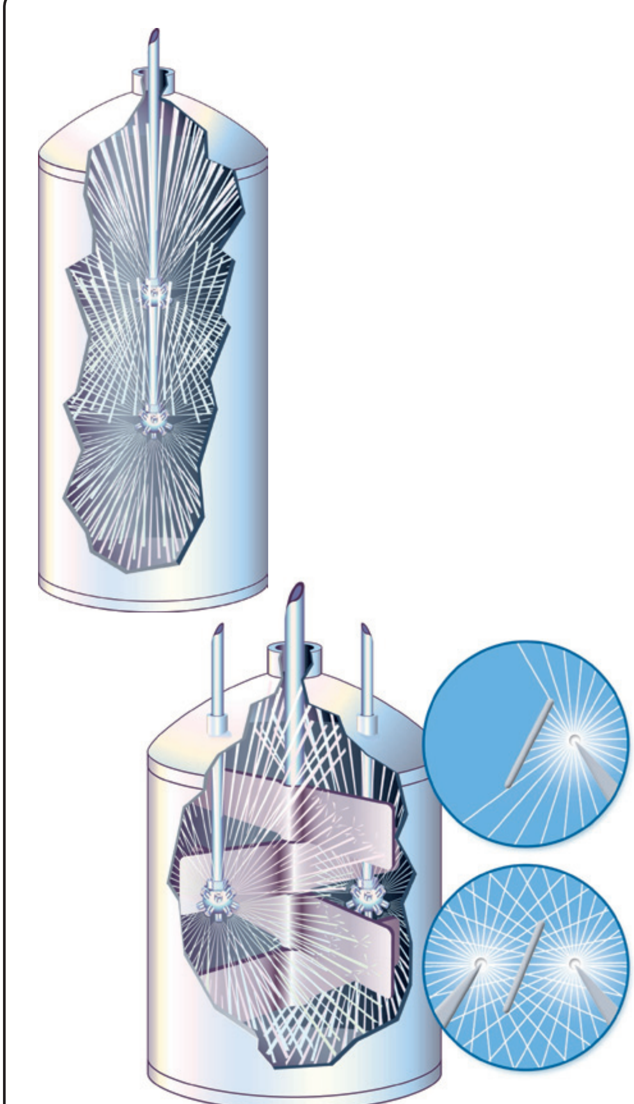

Figure 1. The size of a vessel or internal obstructions may require use of multiple nozzles for effective cleaning.

Fluid-driven machines can achieve comparable cycle times to motor-driven machines by raising pressure. However, operating at higher pressures increases wear of internal parts and results in more frequent maintenance.

Sparking or explosion risks. Explosion-proof electric motors are available or you can use an air motor. Or you may be able to change cleaning solvents to eliminate the explosion hazard without negatively impacting cleaning. Other options include increasing humidity in the vessel to minimize the risk of static electricity, prevent complete drying of the residue and ease residue removal.

OTHER CONSIDERATIONS

Fluid-driven machines generally cost less than motor-driven ones, although the cost depends upon the size of the machine. However, fluid-driven machines have many internal parts and disassembly, replacement and reassembly of worn parts can be time-consuming. In some cases, maintenance requires a special tool kit. Factory refurbishing usually is recommended based on hours of use.

Fluid-driven Machine

Figure 2. Rotational speed depends upon liquid pressure and flow.

Motor-driven Cleaner

Figure 3. Electricity or air can power the motor.

Retractable Head

Figure 4. Cleaning head can be set at any position from zero to full extension.

Motor-driven machines require minimal maintenance and are serviced easily by the user. The motors are positioned outside the tank, ensuring long life and minimal exposure to harmful solvents.

Which is a better choice? Fluid-driven machines usually cost less. Motor-driven machines are less expensive to operate and maintain. The specifics of your operation such as water quality and hours of use will determine which is more cost-effective.

If you've determined that a motor-driven cleaner is your best choice, you must select between two types:

1. Machines with nozzles in a fixed position. These can be permanently installed or moved from vessel to vessel but the cleaning head is in a fixed position on the unit. Maximum operating pressure is 5,000 psi. Various types of motors are available and users specify extension length, flange size and a two- or four-nozzle hub.

2. Machines with retractable nozzles. These permanently installed units offer a higher level of automation (Figure 4). A pneumatic mechanism inserts and retracts the extension and the cleaning head. A control panel allows setting multiple stopping points between full insertion and full retraction to position the nozzles where more impact is required or to clean around obstructions. The control panel can be located away from the vessel for convenience or safety. Maximum operating pressure is 4,000 psi.

The properties of the residue or the cleaning agents and your desired level of automation will determine which option is best for your operation.

PERFORMANCE VALIDATION

Once you've selected and installed a new cleaning machine, how do you know if it's doing its job?

Visual inspection is one option. Monitor the machine to make sure it's working and inspect the inside of the vessel when the cleaning cycle is complete. Swab or riboflavin tests are common ways to verify cleanliness. Of course, the viability of these approaches depends on the size and location of your vessel.

Another option is using an acoustic monitoring device (Figure 5). A sensor mounted to the exterior of the tank "listens" to the performance of the cleaning equipment and identifies variations from a pre-determined baseline. It instantly can detect rotation failure and changes in rotation speed or spray pressure and can notify operators via audible or visual alarms. The monitoring device also transmits performance documentation for quality control and record keeping. It obviates visual monitoring and post-cleaning tests. ●

Acoustic Monitoring Device

Figure 5. Unit mounted on onside of vessel detects loss of rotation and variations in rotation speed and fluid pressure.

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