
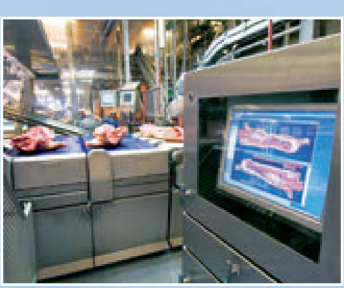
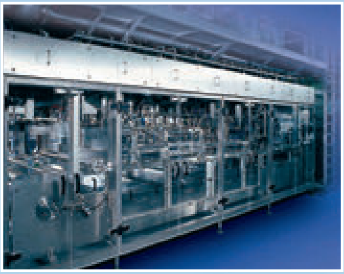



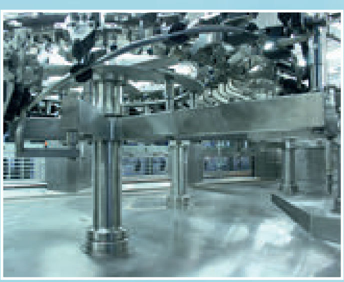


EHEDG
Yearbook 2011/2012

European Hygienic Engineering & Design Group

Tank cleaning technology: Innovative application to improve clean-in-place (CIP)

Tank cleaning technology helps solve the challenge of clean-in-place (CIP) cleaning in difficult-to-clean areas such as closed equipment for liquid processing. Recent innovations in tank cleaning technology illustrate how and why a dynamic and targeted flow significantly improves cleaning efficiency. Implementing tank cleaning technology in other types of equiment can solve cleaning challenges.

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In 2010, the first European Hygienic Engineering & Design Group (EHEDG)-certified rotating spray head for tank cleaning, the patent-pending Alfa Laval SaniMidget SB, was introduced into the marketplace. In early 2011, Alfa Laval will introduce a patent-pending Pasteurized Milk Ordinance (PMO) mix proof double seat tank outlet valve that also utilizes the principle of the hygienically designed spray device. This merger of technologies has helped solve a problematic cleaning task: cleaning of the vent cavity in a PMO mix proof double seat tank outlet valve. Similar cleaning problems often occur inside medium-sized pieces of equipment. A large compartment needs to be continuously flushed, and to achieve adequate cleaning, it must be completely filled with cleaning liquid. A large flow rate of detergent/water is needed to completely fill the large volume inside the equipment during clean-in-place (CIP), or as in the case of the PMO mix proof valve, pressure on the gaskets is not allowed (i.e., the vent cavity of a mix proof valve cannot be filled with circulating water).

The solution to the challenge of cleaning medium-sized processing equipment with as little water as possible (i.e., without needing to fill the equipment completely) is actually straightforward using tank cleaning technology. Remember, cleaning is done at the wall. There is really no need to have a large bulk of liquid that never touches the walls running through the equipment. This is often seen in medium-sized equipment and pipes. To explain the philosophy behind this innovative use of tank cleaning technology, this article describes the progress made in tank cleaning over the years using the tank cleaning technology ladder schematic (Figure 1) and presents a detailed look at the patent pending solution inside the Alfa Laval mix proof double seat tank outlet valve.

The tank cleaning ladder: steps of progress

Historically, the tank cleaning process utilised simple fill-and-dump principles, where the entire tank was filled with detergent, allowed to soak for a period of time, and then the detergent was dumped to drain. However, this proved to be a very time-, water- and detergent-consuming process that relies on the action of the chemistry and temperature.

The first step up the technology ladder for tank cleaning was the introduction of static spray balls, where each ball has a number of drilled holes to form a "shower" (Figure 1). Here, liquid is sprayed from a number of holes in a pre-defined static pattern onto the tank wall. Cleaning is achieved mainly by the liquid that hits the wall and forms a free-falling film down the tank wall. Cleaning is primarily accomplished through soaking and a small amount of force from the falling liquid. The force (wall shear stress) is of the same magnitude as that present in a pipe, in which liquid is pumped through at a flow rate corresponding to average velocity of 1.5 m/s (3-5 Pa). As for the fill-and-dump cleaning method, time is also an important factor; however, the amount of water used is reduced as water is recirculated and only a thin, turbulent, free-falling film on the wall is needed to perform the cleaning (e.g., the rule of thumb is approximately 2 m^3/h per m circumference of the tank). Hence, all of the water that was previously in the bulk of the tank during a fill-and-dump is no longer needed; detergent is supplied to where it performs the actual cleaning.

The second step up the ladder is rotating spray head technology, which utilises a ball with holes or slots that can rotate around an axis (typically, the axis of the supply line) during cleaning (Figure 1). The rotation comes from water being supplied by a supply pipe and into a spray head. The spray head rotates on ball bearings or slide bearings. The rotation comes from the force generated when water is ejected from the slots or holes in the rotating spray head. The cleaning principle is related to that of a static spray ball: free-falling film cleaning with a stronger impact than the static spray ball. The increased impact is due to the fact that the water circulated is focused into only a number of slots or holes, and thereby a higher velocity at the jets is generated at the same flow rate. The main difference is that the water is sprayed onto the tank wall in a dynamic pattern. Hence, the coverage is approximately 100%, whereas the static spray ball does not achieve 100% coverage. The tank wall with direct hit from the jets/fans will experience relatively high-impact cleaning. The boundary layer on the walls will build up and be disrupted again to increase the mass and heat transfer to the soil because the walls are continuously hit by incoming liquid.

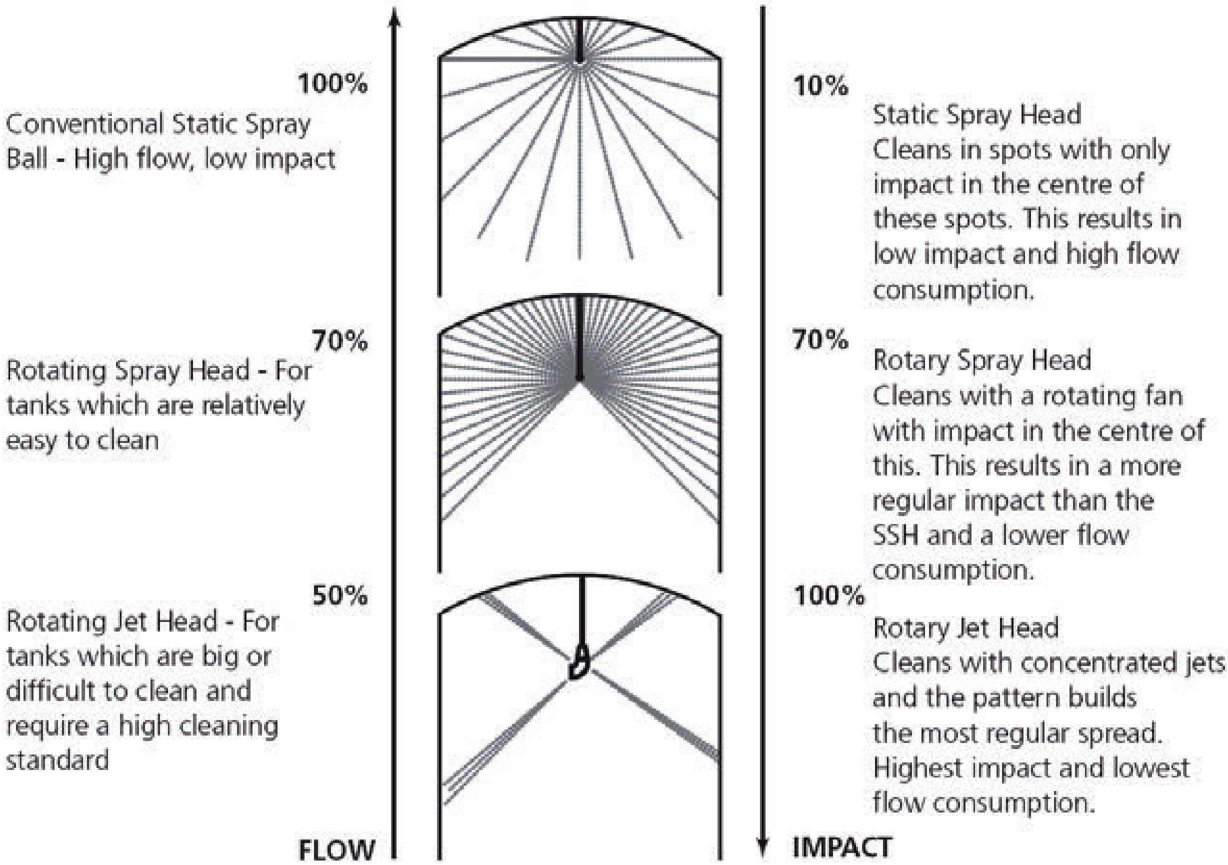

Figure 1. Tank cleaning technology ladder.

The third step up the tank cleaning technology ladder is rotating jet head technology. This technology involves a number of nozzles, mounted in a nozzle head that rotates around a horizontal axis, while the nozzle head is mounted in a body that rotates around a vertical axis. The motion is driven by pumping the cleaning liquid through a turbine and a gearing system. The two-axis rotation of the machine generates a dynamic impact pattern from the jets and allows for complete coverage if installed and operated correctly. The cleaning principle is very different from that of the other tank cleaning technologies because the flow rate used is concentrated in a number of nozzles. Focusing the flow rate allows for local cleaning conditions that are extreme. Compared with other technologies, the mechanical action is much higher. Wall shear stresses in the footprint of the impinging jet start at a magnitude of 10^3 Pa and are reduced to around 50 Pa at a diameter of approximately 100 mm, depending on flow rate and nozzle configuration. Impact force and high wall shear stress in the footprint of the jet that hits the wall means that cleaning is done mainly by force and only a little by the detergent and temperature. On top of the impact cleaning, some soaking takes place as the incoming liquid forms a free-falling film on the wall after the jet has passed an area.

Cleaning time, cleaning liquid and detergent levels can be reduced significantly by focusing flow and running the cleaning in a dynamic fashion. There is no static flow field, which means that boundary layers build up quickly and are disrupted again as the next jet passes through that area. Also, the impact pattern and number of nozzles means that the soil to be removed is affected by the impact and footprint region several times during the cleaning process. From the progress achieved in tank cleaning technology over the years, it should be learned that a piece of equipment or a process line does not necessarily have to be cleaned by pressurising the system, such as pumping pipes full of detergent with recirculation. All the detergent in the centre of the equipment that does not touch the wall does not contribute to the cleaning of the walls. Hence, if the process line/equipment is drainable, the cleaning could be done by spraying detergent onto the walls in a dynamic pattern instead (i.e., as seen with tank cleaning using rotating spray heads or rotating jet heads). Focusing the flow rate available for cleaning into a limited number of jets increases local cleaning conditions where the jets hit the wall. Having these favourable cleaning conditions move around in the process line/equipment ensures a dynamic system of cleaning conditions and full coverage. The larger the equipment or diameter of the pipes, the easier it will be to mount such devices in the equipment/process line.

Today this is done in some duct systems and very large processing equipment (e.g., centrifuges and separators), where a static spray ball or a standard rotating spray head is mounted using separate solution supply pipes coming through the walls of the equipment.

SaniMidget SB principle

The SaniMidget SB was designed to fulfil the 3-A Sanitary Standard (3-A SSI) on spray cleaning devices and has successfully met the objectives of the 3-A Third Party Evaluation program. In the design process, the EHEDG Test Method Doc. 2 was applied in order to provide evidence for the self cleanability of this device and a certificate was obtained.

Figure 2. SaniMidget SB, Alfa Laval.

The SaniMidget SB works in principle by attaching the device to a solution supply tube (Figure 2). The connector holds the stator with the pin-connection that also attaches the device to the supply pipe. Between the connector and stator a rotating element is mounted. This rotating element rotates between two slide bearing surfaces generated by water flowing between one end of the connector and the rotor and between the stator and the rotor. The rotor is open at both ends where it meets the connector and stator. The rotor has a number of slots that generate the rotation and also distribute the liquid onto the tank wall as it rotates. The detergent comes through the downpipe, into the connector, and passes through a number of holes into the rotor from which it flows through the bearing area and the slots in the rotor. The design is extremely simple, can be fully dismantled without tools and is fully inspectable.

Cleaning the vent cavity in a PMO tank outlet mix proof valve

As mentioned above, a new mix proof valve for vertical and horizontal tank outlets will be introduced by Alfa Laval in 2011 (Figure 3). The valve is designed according to PMO standards, for which special rules apply for the design and cleaning of the vent cavity.

For large mix proof double seat tank outlet valves, cleaning of the vent cavity is a challenge. The compartment has a relatively large volume that must have a cross-sectional area equal to or larger than the cross-sectional area of the product pipe line. Also, according to the PMO (3-A SSI Standard 85-01), the vent cavity is not allowed to be pressurised during cleaning and impingement on the gaskets is not allowed. This limits the cleaning methods that can be chosen.

Conventionally, the cleaning of the vent cavity in mix proof double seat tank outlet valves is done by flowing liquid through the annulus between the spindle and the valve stem. This liquid then flows out and runs along the curved surface of the valve plug and back down the inside of the second valve stem, further down past the sealing element (shown as (1) in Figure 3), along the inside walls of the vent

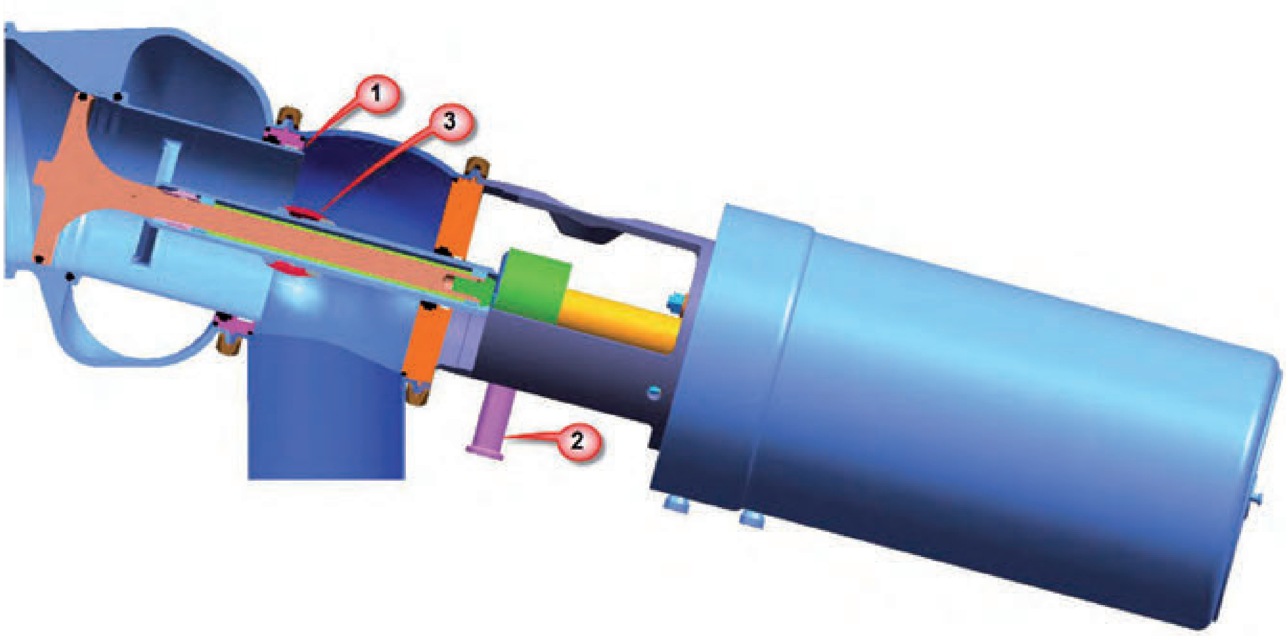

Figure 3. PMO mix proof valve for horizontal tank outlet: (1) sealing element, (2) liquid supply line for cleaning liquid and (3) rotating element.

cavity, and finally, out to drain. The PMO regulation does not allow pressurisation of the vent cavity. Thus, filling the cavity and recirculating is not an option in this case. The conventional method of cleaning the vent cavity can be problematic, especially around the sealing element (1) and the wall just after the sealing element. The sealing element creates a shadow zone and a corner that is almost impossible to clean with the liquid coming from the curved surface of the valve plug. In addition, the wall in the vent cavity on the opposite site of the pipe to drain is a problematic location to clean because the liquid will go towards the pipe to drain due to gravity instead of flowing along the walls opposite and next to this pipe to drain.

Another option for cleaning could be to use one or several static or rotating spray device(s) that can clean the surfaces of the vent cavity. The external connection would then be placed through the valve body. This would require additional piping for supplying these spray devices and there would be shadow zones generated by the valve stem and also the supply lines themselves.

Experimental cleaning trials with the valve proved that there were areas that were almost impossible to clean with traditional methods (around the sealing element (1) and the walls after it). Also, using stationary spray devices did not create impact on all of the surfaces to be cleaned. Hence, alternative methods are needed to produce effective cleaning using minimum water.

The straightforward alternative to this is to adapt tank cleaning technology, as the drain area can in fact be seen as a small tank. As shown in Figure 3, the design of this new mix proof double seat tank outlet valves already has a detergent supply from the outside (2) and through the clearance between the stem and the spindle for cleaning the curved part of the valve plug that faces the vent cavity. By exploiting this together with the principle of the SaniMidget SB, it was possible to put a rotating spray head (3) around the spindle. The rotating head is fed with liquid from a number of holes in the spindle, and bearing surfaces are created on the spindle, as well. As liquid is pressed through the bearing surfaces and slots in the rotating element, rotation is created and liquid is distributed throughout the entire vent cavity with no shadowing effect from the spindle (stem) as would have been the case if spray devices were mounted on separate supply lines through the valve body.

This patent-pending design has allowed an extremely efficient cleaning of the vent cavity at a low flow rate. The entire vent cavity can now be cleaned at approximately the same time, since all surfaces are exposed to impacting water from the rotating element. There are no areas significantly more difficult to clean than others.

Conclusion

The synergy of joining state-of-the-art tank cleaning equipment and cleaning philosophy with novel valve technology has allowed a unique solution for easier cleaning of large compartments in processing equipment. Previously, it was only possible to clean by pressurising equipment with water at a high flow rate to perform the cleaning. In the case of the PMO mix proof valve, it is even more crucial as the compartment to be cleaned cannot become pressurised. The insertion of a rotating spray head on a cylindrical shape that allows cleaning liquid to flow through and into the rotating spray head has proven to be an effective cleaning method for cleaning larger compartments without installing numerous spray devices to compensate for shadow areas. Further, a dynamic cleaning effect from the rotating spray device also improves the cleaning mechanisms by increased coverage, increased impact cleaning and increased heat and mass transfer from the non-stationary liquid film generated on the surface to be cleaned.

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