Development of Spray Ball™ for Tank Cleaning

1. Introduction

In recent years, CIP (Cleaning In Place) with little or no involvement of workers has become the mainstream for assembling and removing of industrial tanks and pipes, etc.

This report focuses on cleaning nozzles for cleaning in tanks in various industries and introduces the Spray Ball™ (fixed type) and Rotary Spray Ball™ of our products and new Rotary Spray Ball™ of our developed products.

Cleaning validations are being implemented for facility equipment in critical processes in the pharmaceutical industry. Our Spray Ball™ has also been adopted as an important part of cleaning equipment, contributing to the risk management of our customers.

2. What is cleaning?

In this report, we define cleaning as removing the dirt (solid substance adhering to the surface) to the extent that there is no problem for the post-process treatment and processing.

In a broad sense, the cleaning also includes removing impurities in the gas or liquid, but it is excluded here.

The cleanliness of cleaning varies by purpose and use from a level of 100% removal of deposits to a level of acceptability when it is apparently reduced, and there is a wide range of demands from each industry.

3. Spray Ball™ (fixed type)

Fixed type Spray Ball™ is used for cleaning tanks such as reaction tanks, stirring tanks, and storage tanks in all industries, such as medical, chemical, and food products. Since the wetted part is PTFE having heat and chemical resistance characteristics, makes it possible to permanently install the product inside a tank. In addition, since the spraying position is designed according to the customer's tank nozzle orientation, efficient cleaning is possible in a short time and the consumption of cleaning liquid can be suppressed.

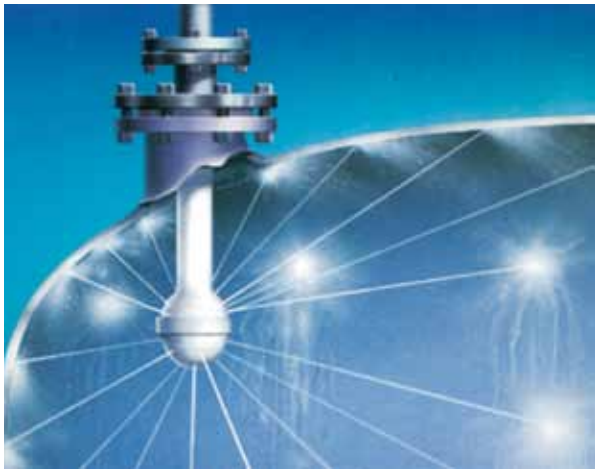


Figure1 Image of Spray Ball™ (fixed type)

The holes are efficiently arranged by high-precision machining, and pressure is applied from a small hole to inject. If the fluid is flammable, conductive PTFE is recommended as the material. This is because static electricity accumulates during injection, which might cause firing.

Table1 The number of Spray Ball™ per tank volume

Tank volume	The number of Spray Ball™		
	Type	Vertical reaction tank	Vertical storage tank
～600ℓ	50	2	1
1～5㎥	80	2	1
6～10㎥	100	2	1

Note: The number of units used in the above table is an example.

Table1 shows the approximate required number of Spray Ball™.

If there are stirring shafts, baffles, etc. in the tank, it is recommended to increase the number of Spray Ball™ to clean the backside of the shaft.

The structure consists of ① upper ball ② lower ball ③ two-stage flanges as shown in Figure1 & 2. A two-stage flange is used to prevent misalignment so that the jet can be precisely sprayed to the intended cleaning point.

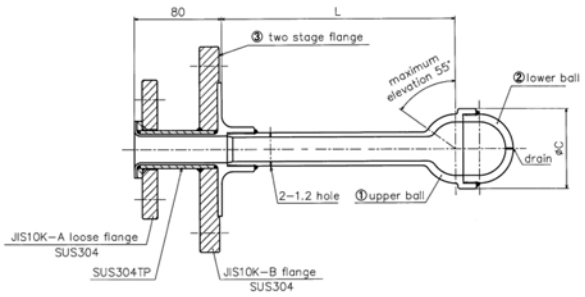


Figure2 Standard design of Spray Ball™ (fixed type)

Table2 shows the standard dimensions.

Table2 Standard dimensions

Type	Cleaning water vlume (L/min)	Flange combination	φC	L (maximum)	
				PTFE	Conductive PTFE
SB-50	15～40	25A×50A	46	400	300
SB-80	30～70	25A×80A	72	600	370
SB-100	70～100	40A×100A	97	500	370

When attaching the Spray Ball™ to a T-tube, etc., attach a joint or steady rest. This is to prevent the warpage due to the concentration of holes at certain locations and the application of spraying pressure.

For the flange combination, besides Table2, the size can be specified. The material of the flange is SUS304 as standard, but other materials such as SS400 can also be specified.

4. Rotary Spray Ball™

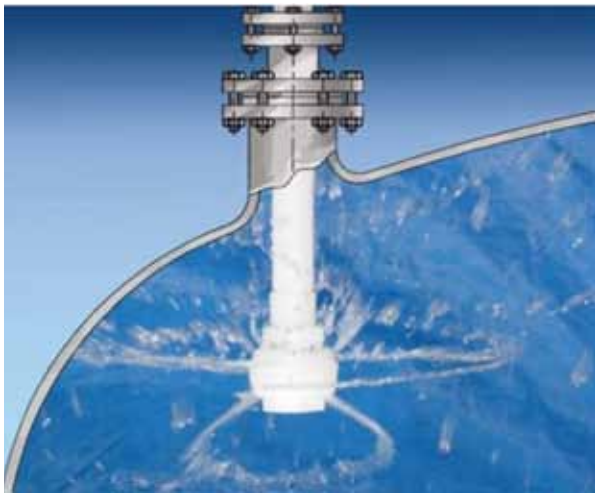


Figure3 Image of Rotary Spray Ball™

Rotary Spray Ball™ is similar in application and material properties to fixed Spray Ball™ but has the following features.

- Rotary Spray Ball™ is composed of ① body ② upper ball ③ lower ball ④ fixed ring ⑤ collar as shown in Figures4. The upper and lower balls rotate reversely. Since the cleaning water itself controls the rotation, there are no parts for rotation inside. Because of the simple structure, we can easily maintain this.
- Even at low pressure, we can clean efficiently because the spraying pattern makes a straight bar flow.
- The spraying pattern (angle) and flow rate (hole diameter/number of holes) can be changed depending on the customer specifications.

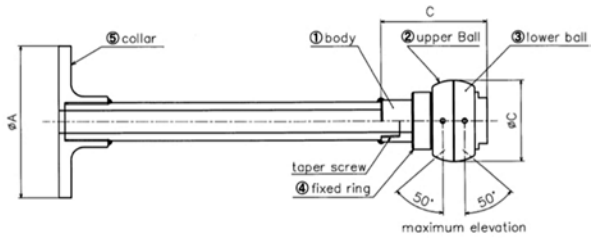


Figure4 Standard design of Rotary Spray Ball™

The mounting method is to insert the collar ⑤ between the nozzle of the tank and the nozzle on the piping side. This is because the Rotary Spray Ball™ needs

not to spray at the target point, unlike fixed type Spray Ball™.

Table3 shows the standard dimensions.

Table3 Standard dimensions

Type	Cleaning water vlume (L/min)	φA	φB	C	Taper screw
SB-50R	25	100	42	57	1/2"
SB-80R	90	130	64	86	3/4"
SB-100R	140	155	88	118	1"

5. Selection of fixed type or rotary type

So far, we have described Spray Ball™ (fixed type) and Rotary Spray Ball™, but we have received a lot of feedback about which one should actually be installed, so we compare the features of each one in a Table4.

Table4 Comparing fixed type and rotary type Spray Ball™

Type	Cleaning water vlume	Cleaning time	Spraying target	Maintenance	Cost
Fixed	○	○	○	△	○
Rotary	△	△	△	○	○

Regarding the amount of cleaning water, cleaning time, and point cleaning, since the fixed type targets the point for cleaning, it is possible to perform more efficient cleaning than scattering the cleaning liquid like a rotary type, to suppress the amount of cleaning water and cleaning time.

On the other hand, the rotary type is suitable for the rinse in the tank, and it is easy to disassemble and maintain because of the simple structure. In addition, since the hole diameter is large there is no concern about clogging.

6. Cleaning challenges

6-1) Background

The issue of tank cleaning is cleaning inside each nozzle.

Conventionally, if head of tank, manholes(hand holes), and lighting hole (through-lamp openings) in the tank were able to be cleaned, the cleaning inspection would have passed. But in recent years, it would have been judged to be unacceptable if it could not be cleaned to the inside of each nozzle, not limited to the particular industry.

In the background, small parts such as inside the nozzles that cannot be cleaned with Spray Ball™ have been cleaned manually by workers using brushes or cloths. As a result, cloth fibers and dust remained in the tank due to human intervention, causing serious damage to the post-process. This is so-called contamination problem.

Therefore, each industry has proposed CIP that requires no human intervention with the goal of eliminating contamination. Another advantage of CIP is that a certain cleaning effect can be expected so that the product quality can be stabilized and improved. Because of these factors, CIP became the mainstream, and cleaning nozzles attracted attention.

6-2) Solutions

First, the cleaning inside each nozzle was examined using a fixed type Spray Ball™. When cleaning with this product, it is possible to clean by increasing the length of the pipes as shown in Figure5 and spraying them into the nozzles from the downward direction. However, because the maximum elevation angle is 55°, as shown in Figure2, the area above the fixed type Spray Ball™ cannot be cleaned. In addition, designing the spraying point for each customer's tank nozzle orientation is a laborious work.

Next, Rotary Spray Ball™ is examined. When cleaning with this product, it is impossible to wash the inside of the nozzle because the maximum elevation angle is 50° as shown in Figure4 and only specific spray axes pass through.

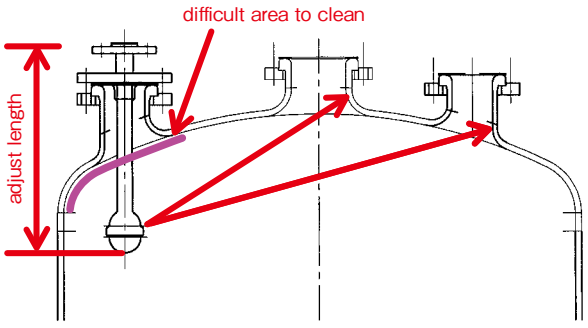


Figure5 Washing image of each nozzles

7. New developed product Rotary Spray Ball™

As described above, it takes time to design the Spray Ball™ (fixed type) and the inside of the nozzle cannot be cleaned with the conventional Rotary Spray Ball™. So we have newly developed a "Slit type" and a "Hole Pattern type" to meet customer requirements. Next, the features of each developed product are explained.

Figure6　New developed Spray Ball™

7-1) Slit type

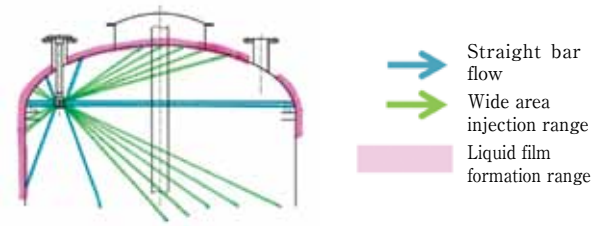


Figure7　Cleaning image of Slit type

The structure and material of the Slit type are the same as the standard products. The upper and lower balls rotate in the reverse direction and efficient cleaning is possible. Clean directly above and below the area where cleaning is impossible, using a straight bar flow, and clean manholes, lighting ports and nozzles with a wide area jet (slit). (Figure7)

The spraying pressure is slightly weaker than the hole shape due to the widened slit opening, but the spray is wider, so it is better at cleaning a wider area than the hole.

7-2) Hole Pattern type

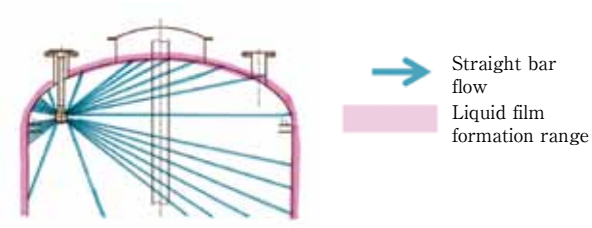


Figure8　Cleaning image of Hole Pattern type

The structure and material of the Hole Pattern type are the same as the standard products, upper and lower balls rotate reversely. It can clean directly above and below the nozzle tending to be unavailable for cleaning owing to the straight bar flow. And it can also clean the manhole, lighting hole, and each nozzle by small holes vertically arranged in two rows. This hole reaches the cleaning point while keeping water pressure, so it exhibits high cleaning power like fixed type Spray Ball™. The distance between the holes is made close by our unique design and processing, which makes it possible to enter each nozzle.

In addition, the efficient cleaning is possible, because the rotation speed is also low compared with the Slit type (Figure8).

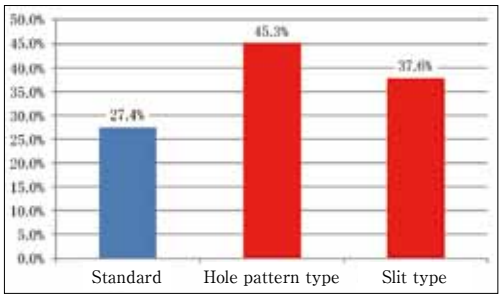
7-3) Comparison of cleaning rate between standard Rotary Spray Ball™ and newly developed Products

Figure9 shows the comparing the result of cleaning rate between the newly developed product as "Slit type" and "Hole Pattern type" and conventional Rotary Spray Ball™.

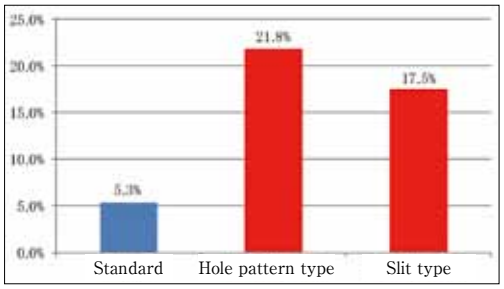
As observed from this result, the developed products as Slit type and Hole Pattern type are superior to the standard product in cleaning in the tank and in the nozzle. The Slit type can clean a wider area in a short time and the Hole Pattern type reaches the cleaning point while keeping strong pressure, so it is especially superior for cleaning in the nozzle.

This cleaning evaluation test is the result described in the following section 8 "cleaning evaluation test" devised by our company. The value in the graph is lower because the material having high adhesion and dirty is used to carried out the evaluation test under

severe conditions.



Cleaning rate of the tank inside



Cleaning rate of the nozzle inside

Figure9 Cleaning rate of the tank and nozzle inside

8. Cleaning evaluation test

Typical cleaning evaluation methods include visual inspection, solvent extraction using water, and sampling from the surface. When determining the cleaning evaluation method, it is necessary to first consider the general dirt related to the target equipment and select an appropriate cleaning evaluation method.

Table5 summarizes typical cleaning evaluation methods and their advantages and disadvantages.

Table5 Comparison of cleaning evaluation methods

Evaluation method	Advantage	Disadvantage
Visual inspection	・Easily implementable ・Surface dirt can be detected ・No need for analyzer	・Subjective ・Cannot detect the entire equipment ・Low concentration substances cannot be detected
Rinsing water sampling inspection	・Easily implementable ・Can detect detergents and other water-soluble substances ・Can be used for daily monitoring of the cleaning cycle	・Adhesive residue cannot be detected ・High precision analysis
Swab inspection	・Can be detect attached substances	・Depending on inspector results may vary ・It is necessary to enter or disassemble the equipment

The cleaning evaluation test method and inspection timing are specified in the operation manual of each company, and no particular standards are set in each industry.

Our customer may performt the cleaning evaluation test when delivering our Spray Ball™ products. The purpose is to attach Spray Ball™ to the customer's tank and check if cleaning at the level requested by the customer is possible. In this case, visual inspection is the mainstream. The method is to spray riboflavin or food coloring (viscosity is about 100cp), which looks like dirt was sprayed thoroughly into the tank and then operate the Spray Ball™ for about 1 to 2 minutes (depending on the customer). After that, visually check that the dirt has been removed. In the case of riboflavin, it is easy to find dirt because it is reflected by illuminating the black light, but care should be taken in handling because it has the property of being vulnerable to light. Food coloring is often used because they are available and handy. In the case of visual inspection, as shown in Table5, there is an advantage that it can be easily implemented and an analyzer is not required, but there is a disadvantage that the determination level is affected by the knowledge and experience of the assessor. Therefore, in order to eliminate such differences, a new method was devised for simply quantifying the cleaning evaluation test results. The advantage of this evaluation method is that a cleaning evaluation test can be easily performed at a low cost because special materials and analytical equipment are not required, and the result can be obtained immediately. Also, Since it is possible to quantify the value different from visual inspection, there is no concern that the judgment level is influenced by the judgment person. The challenge is that it is difficult to test the entire equipment and it is necessary to enter into the equipment.

Now, we are trying to improve this new method for practical application.

9. Conclusion

This report introduces the cleaning nozzle in the cleaning tank and a new cleaning evaluation test. So far, we had only two types of cleaning nozzle, fixed and rotary type, so it was difficult to respond to a wide range of customer needs.
The development of new cleaning nozzle "Slit type" and "Hole Pattern type" has made it possible to provide various spraying patterns. We hope that our customers will be able to select a cleaning nozzle suitable for each application in the future.

In addition, developing from conventional technology, we have successfully quantified the cleaning evaluation test. Starting with this research, we would like to try to further improve the cleaning rate and devise new cleaning methods and strive to develop services adapted to the times and the environment.
We will continue to pursue true customer needs and make efforts to provide new products and services.

10. References

1) Valqua Valflon Lining Catalog

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