Part I

MU-SSPW Industrial Wastewater Treatment System for Wastewater Containing Organic Calcium and Chlorine Compounds

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Introduction

The "MU-SSPW" (MU-Static Spiral Perforated Wings) represented a breakthrough in tower internals when we launched it 31 years ago, since when it has been put to a wide range of uses—including mixing, absorption, desorption, reaction, cooling, dispersion, distillation, and extraction—wherever liquids, gases, and powders are handled.

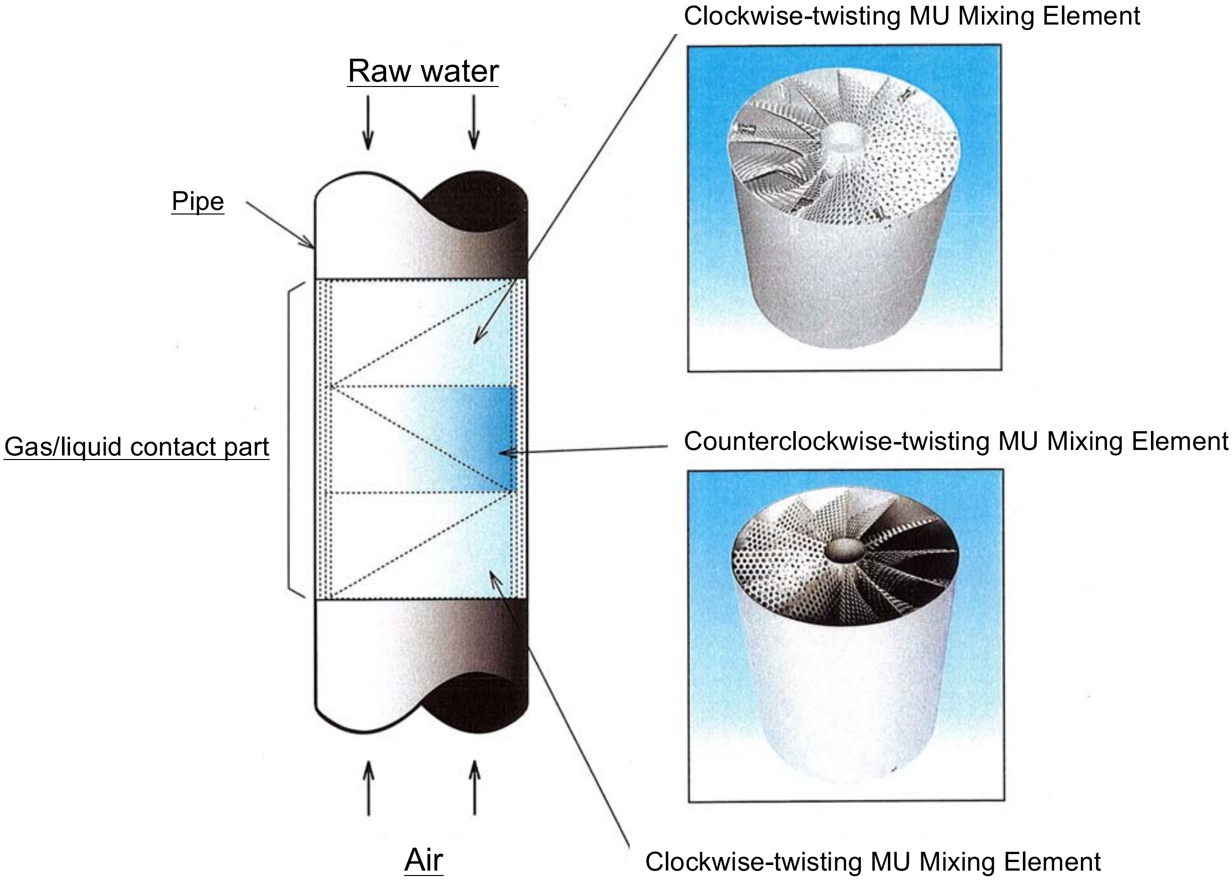

Figure 1 Basic structure of the MU-SSPW

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During that time, it has acquired an enviable reputation for its proven high performance, maintenance-free operation, energy efficiency and space-saving characteristics. The MU-SSPW, which is a component part of the MU Mixing Element, has drawn particular interest in recent years as a solution to the environmental challenges posed by emissions of exhaust gas and wastewater and the need to conserve energy.

1. About the MU-SSPW

1-1 The MU-SSPW consists of a cylindrical element, as shown in **Figure 1**. This comprises two types of two high-performance agitator "wings"—one twisting clockwise and the other counterclockwise—that ensure high-performance gas-liquid contact efficiency. These wings are perforated to allow gas to pass through.

Liquid and gas are thoroughly mixed by the element through a process of repeated division, merging, inversion, and shearing. The idea of effecting dynamic motion in the radial and axial directions was inspired by the flow of a waterfall, surging downward like a cloudy white wave, and is the outcome of the pursuit of the ultimate matter and heat transfer between different fluids.

1-2 **Figure 2** shows a comparison with the packing and trays that form the internals of conventional systems. Packing makes it easier for fluids to descend along the wall of a column and, conversely, for gases to blow through the center where resistance is lower.

Structurally, trays have dead ends that cause the flow of liquids to stagnate at each end of the tray floor. These require a downcomer part to change the direction of flow, and this reduces a tray's effective area. Although manufacturers have tried various ways of ameliorating this problem, they have yet to find a definitive solution.

1-3 As explained in 1-1, the MU-SSPW is fundamentally different in concept from conventional internals.

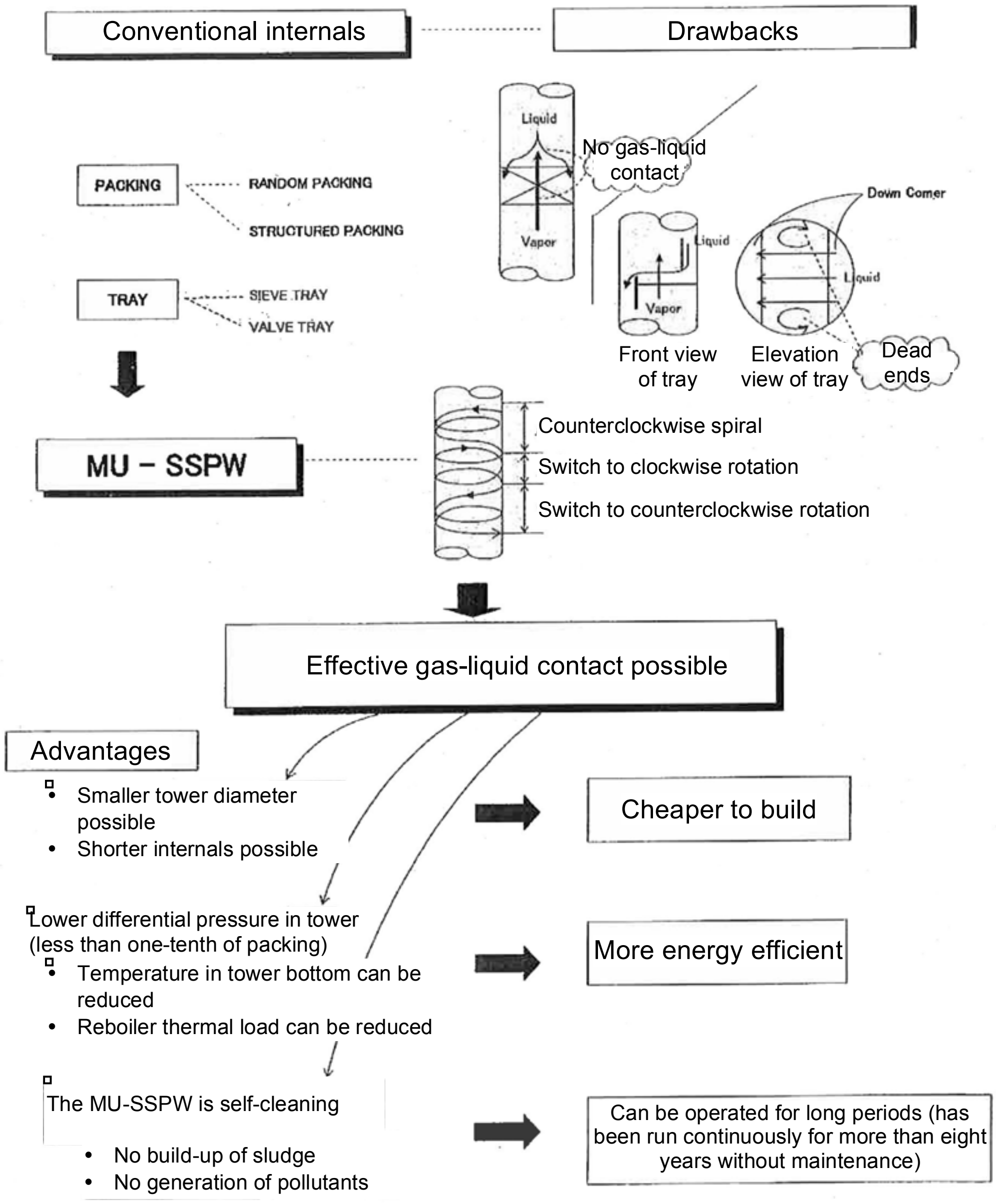


Figure 2. "MU-SSPW" MU-Static Spiral Perforated Wings – a revolution in tower internals

2. Features of the MU-SSPW

The MU-SSPW offers especially outstanding performance in the following three respects.

(1) Can be designed for gas superficial velocities of 2-6 m/s

This is considerably higher than with conventional internals, and is possible because of the low differential pressure and resistance to entrainment that result from the MU-SSPW's effective use of tower cross-section. It also has a high gas-liquid contact efficiency, which yields the following benefits.

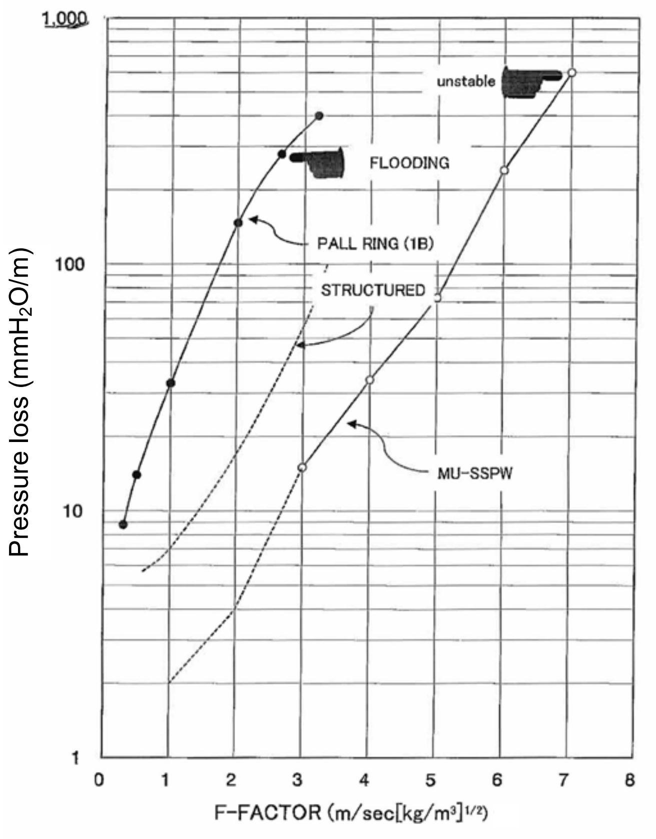
Tower diameter can be halved or more compared with conventional internals, and the height of internals can also be reduced. This allows the footprint as well as the column itself to be made more compact, and reduces the cost of construction.

(2) **Figure 3** shows a comparison of pressure loss at low differential pressure.

These are the results obtained from tests on a water-air system. The MU-SSPW has a low differential pressure that is one-tenth that of packing, which means that the operating temperature at the bottom of a tower can be lowered. This helps save energy and prevent fouling.

(3) The third and most well received aspect of installing a MU-SSPW is that it makes possible long-term stable operation.

As explained above, the MU-SSPW's structure ensures that liquid is repeatedly and dynamically inverted as it descends without creating any dead ends. The MU-SSPW is thus always automatically cleaning as it operates, as a consequence of which no sludge build-up or pollutants are generated and no blockages occur. Towers equipped with MU-SSPWs that are repeatedly cleaned once every four months have been in continuous, maintenance-free operation for over eight years.



□

$F - FACTOR = U_G\sqrt{P_G}$

U_G: Superficial velocity (m/s)

P_G: Superficial density (kg/m3)

< Measuring conditions >

Pressure: atmospheric pressure

Fluid: water/air

Water flow rate: 31 m^3/m^2/hr

Figure 3 Pressure loss comparison (counter flow)

Example of application

This example illustrates the major benefits to be derived from making effective use of the MU-SSPW's self-cleaning action.

This unit strips and removes organic chlorine compounds from process wastewater in a tower equipped with sieve trays. This wastewater also contains calcium-based material, which tends to precipitate in the tower (especially in the sieve tray downcomer), and so caused blockages that necessitated shutting the unit down every four months to open it up for cleaning. As a reboiler could not be used due to the severity of the blockages caused by calcium-based material, the approach employed was to blow raw steam directly into the bottom of the column.

The wastewater contains 300 wt.-ppm of chlorine-based organic compounds, at least

90% of which is removed and recovered at the top of the tower and recycled by other processes. The tower has a diameter of 2.8 m and eight layers of sieve trays, and works by a process of decompressed steam distillation. As the efficiency of removal of chlorine-based organic matter progressively deteriorated as fouling of the downcomer worsened, this had to be countered by, for example, increasing reflux volume and reducing wastewater throughput. Eventually, continuous operation became impossible and the unit had to be repeatedly shut down and opened up for cleaning.

The challenge was to eliminate the fouling and blockages inside the tower that were the root cause, and these problems were resolved by using an MU-SSPW in place of the sieve trays that formed the internals.

Results of modification

Elimination of the fouling and blockages inside the tower, which was the primary objective, was achieved by means of the self-cleaning action of the MU-SSPW described above, thus making possible stable long-term operation. Eight years since the modification was made, the rate of removal of organic chlorine compounds has been maintained at a minimum of 95% and operation at stable low differential pressure continues.

Inspections of the interior when the system has been periodically opened up have also confirmed the absence of fouling and blockages to the trays and downcomer.

Figure 4 shows a comparison of the tower specifications and operating results of “conventional” and “modified” units.

In addition to the elimination of fouling and blockages, the following ancillary benefits were achieved.

(1) Steam use was slashed by two thirds, contributing to significantly lower running costs (Figure 4 (1)).

Conventional system → MU-SSPW system

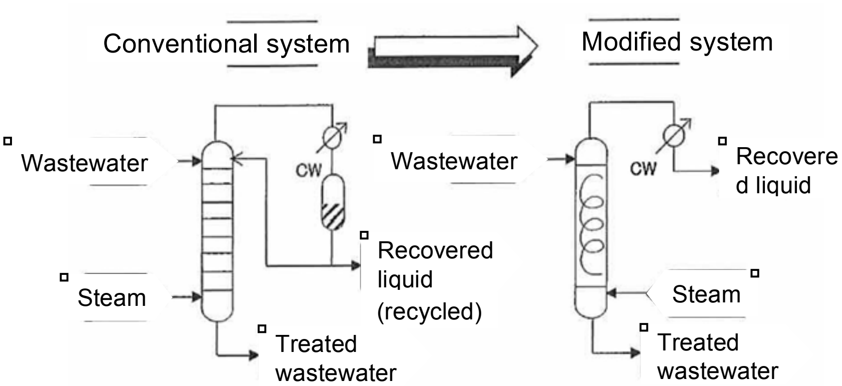
12 t/hr×8,000 hr/yr＝96,000 t/yr 4 t/hr×8.000 hr/yr＝32,000 t/yr

(96,000－32,000 t/yr)(¥3,000/t)=¥1.92 million/yr reduction

(2) Zero maintenance costs due to elimination of need to open up for cleaning (Figure 4 (2)).

Approx. ¥20 million/time×3 times/yr= ¥60 million/yr saving

(3) Recovery and recycling of organic chlorine compounds at a stable level of efficiency allowed the cost of chemicals used to be reduced.



Column specifications			
Internals	Sieve trays	MU-SSPW	
No. of layers/height	8 (layers)	9(m)	
Column diameter (m)	2.8	1.5	
Performance			
Wastewater throughput (t/hr)	400 - 600	600	
Calcium-based material in wastewater (wt %)	5		
Organic chlorine compounds in wastewater (wt.-ppm)	300		
Organic chlorine compounds in treated wastewater (wt.-ppm)	20 - 30	10	
Removal rate (%)	90	95% or over	
Reflux ratio (reflux/recovered liquid)	2 - 3	0	
Steam consumption (t/hr)	12	4	(1)
Steam speed in column (m/s)	1 - 1.5	2 - 4	
Total differential pressure (mm H_2O)	700	150 or under	
Continuous running time	4 months	Over 8 years	
Stoppages for maintenance (per year)	3	0	(2)

Figure 4 Column specifications and performances of conventional and modified systems

Conclusion

This paper briefly described one application of MU Company's MU-SSPW technology to the stripping of organic chlorine compounds from wastewater.

Evident from this is how the MU-SSPW's self-cleaning action has made possible stable long-term operation. Our aim now is to pursue application of the MU-SSPW's potential in a wider range of fields beyond simply mixing, absorption, desorption, reaction, cooling, dispersion, distillation, and extraction.