

Application of Ceramic Flat Sheet Membranes to Water Purification Processes

Keywords Ceramic flat sheet membrane, AMST certification, NSF certification, Water purification process

Abstract

Meiden's ceramic flat sheet membranes offer various strength points of physical robustness compared with existing polymeric microfiltration membranes, chemical strength against cleansing chemicals, and expected longer operational life.

Taking advantages of these points of strength, we developed our business mainly in the field of industrial wastewater waste water treatment.

To promote the application of our products to water purification processes, we also developed water treatment technologies by using ceramic flat sheet membranes and tried to acquire international technological certifications needed in various countries and conducted various field tests at home and abroad. As a result, our ceramic flat sheet membrane units were applied to many water purification facilities located in Singapore, Japan, China, and Saudi Arabia.

1 Preface

For the improvement of the quality of treated water and labor saving facility management, application of membrane filtration technologies is widely spread over to water treatment facilities, ranging from drinking water treatment plants to wastewater and sewerage treatment facilities. For water processing filtration membranes used in these facilities, polymeric microfiltration membranes have conventionally been adopted. Recently, however, there are many cases of adopting ceramic membranes for its outstanding characteristics.

Drawing on our engineering resources from our ceramics-related technologies cultivated for many years in the field of our SORESTER (lightning arrester) elements, we developed and commercialized our original product of precision ceramic filtration membranes and delivered such products to Japan and overseas markets for wastewater treatment⁽¹⁾. In parallel, we also promoted the development, verification, and certificate acquisition on our water purification systems where ceramic flat sheet membranes are actively used⁽²⁾. So far, we have delivered our ceramic flat sheet membranes to various water purification facilities at home and abroad. This paper introduces applications of these ceramic flat sheet membranes units to water purification

plants in Singapore, China, and Saudi Arabia.

2 Ceramic Flat Sheet Membrane

The ceramic flat sheet membrane element is a flat plate of a W281 × H1046 × T12 mm (membrane thickness 6 mm) and is a precision microfiltration membrane with a nominal pore size of 0.1 μm. It is made of ceramic with alumina as the main component. The membrane area per membrane element is 0.5 m². Fig. 1 shows a ceramic flat sheet membrane element. Clear filtered water can be obtained by immersing a membrane unit containing multiple flat ceramic membrane elements in the water to be treated. The raw water is sucked up with a pump and the system performs gravity filtration



Fig. 1 Ceramic Flat Sheet Membrane Element

An external appearance of the ceramic flat sheet membrane element is shown.

using the difference in the water head. Fig. 2 shows the ceramic flat sheet membrane unit CH250-1000TM100-U2DJ. Table 1 shows the specifications of the ceramic flat sheet membrane unit. Fig. 3 shows the ceramic flat sheet membrane filtration flow (using a filtration pump).

Since the surface of the ceramic flat sheet membrane is hydrophilic and smooth, it is difficult for dirt



Fig. 2 Ceramic Flat Sheet Membrane Unit CH250-1000TM100-U2DJ

An external view of the ceramic flat sheet membrane unit is shown.

Table 1 Specifications of Ceramic Flat Sheet Membrane Unit

A lineup table of two types of membrane units is shown. Between these types, there is a difference in the number of membrane elements to be accommodated.

Item	Specifications	
Type	CH250-1000TM100-U1DJ	CH250-1000TM100-U2DJ
Effective membrane surface area (m ²)	100	200
External dimensions (mm)	W2060 × H1734 × D720	W2116 × H3280 × D720
Mass (dry state) (kg)	630	1185

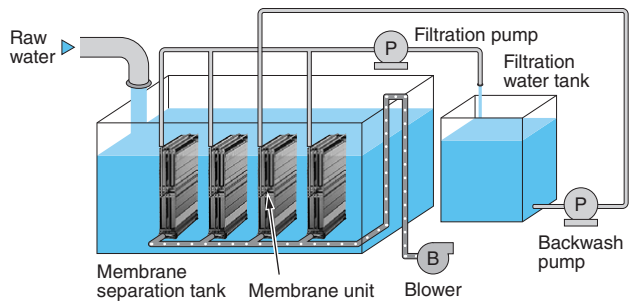


Fig. 3 Ceramic Flat Sheet Membrane Filtration Flow (Using a Filtration Pump)

Membrane filtration is performed by submerging the ceramic flat sheet membrane unit in a water tank and operating a filtration pump for suction filtration.

to adhere, and even if adheres, it is easy to remove. It is physically robust and can be used at higher water temperatures than polymeric membranes. It is also chemically stable, and its strength is not degraded even after repeated contact with chemicals during membrane cleaning to eliminate clogging that occurs with use. Stable filtration can, therefore, be expected for a long period of time. In addition, it does not require special considerations such as immersion in a preservative solution and can be stored for a long period of time in a dry state. Another advantage is that after use, the material can be recycled.

3 Certification in Field of Water Purification

Membrane modules used in water supply facilities in Japan must conform to facility standards stipulated in the Water Supply Service Act. The Association of Membrane Separation Technology of Japan has established the “AMST-001 Standards for MF and UF modules for drinking water use” and certifies membrane modules for water supply that meet facility standards. In August 2015, our ceramic flat sheet membrane unit received AMST-001 conformity approval.

On the other hand, in many overseas markets, filtration membranes used in water supply facilities comply with the National Sanitation Foundation (NSF) International Standards: “NSF/ANSI 61: Drinking Water System Components – Health Effects” and “NSF/ANSI 419: Public Drinking Water Equipment Performance – Filtration” Such certifications may be required. For this reason, our flat ceramic membranes have also obtained these two certifications.

Fig. 4 shows the NSF/ANSI 419 certificate.



Fig. 4 NSF/ANSI 419 Certificate

This shows a certificate relating to the filtration performance of membranes.

4 Application of Ceramic Flat Sheet Membranes to Water Purification Processes

4.1 A Case in Singapore

In 2017, we delivered a large membrane filtration system using submerged ceramic flat sheet membrane units to Chestnut Avenue Waterworks in Singapore, where a submerged polymeric hollow fiber membrane filtration system has been in operation since 2003. To enhance the treatment capacity, a ceramic flat sheet membrane filtration system was installed in the existing spare empty tanks. With a capacity of 36,400 m³ per day, this facility is one of the world's largest drinking water treatment plant for surface water, which utilises a submerged ceramic flat sheet membrane. Fig. 5 shows the treatment flow of this drinking water treatment plant. Fig. 6 shows a part of the ceramic flat sheet membrane

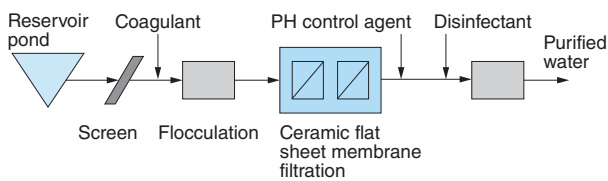


Fig. 5 Treatment Flow of Ceramic Flat Sheet Membrane Water Purification at Chestnut Avenue Waterworks

The raw water taken from the reservoir is added with a coagulant for flocculation. The flocculated water is then passed through the ceramic membranes directly without going through the sedimentation process.

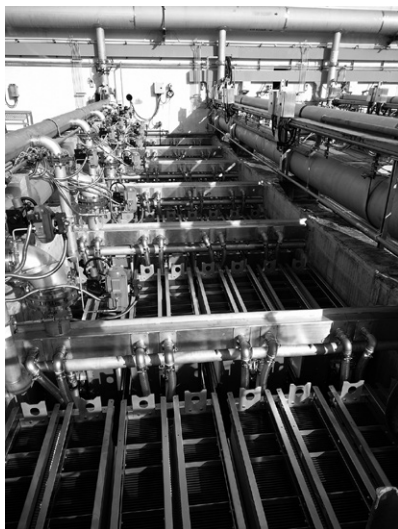


Fig. 6 Ceramic Flat Sheet Membrane Water Purification Facility at the Chestnut Avenue Waterworks

At the Chestnut Avenue Waterworks, ceramic flat sheet membranes were installed in the existing spare empty tank.

water purification facility. This filtration system employs gravity filtration that utilizes the difference in water head and does not require membrane air cleaning during membrane filtration. Aeration of the membranes is only required during back washing. The new system consumes less power during operation than polymeric hollow fiber membranes and a membrane integrity test is automatically performed once a week to ensure the integrity of the membrane. The ceramic membranes have been in operation for more than five years since June 2017 and the operating system remains stable.

4.2 Cases in China

In China, construction projects for water purification facilities are increasing to improve the coverage of the water supply system in rural areas. Until now, sand filtration was the most common method of water purification in China, but the use of membrane filtration is increasing to improve the quality of purified water.

In mountainous rural areas, it is difficult to lay water pipes over long distances, and there is a need for small-scale distributed water purification facilities that are relatively easy to maintain and manage. There are many slopes on site and water purification treatment by gravity filtration using the difference in water head is expected. Our ceramic flat sheet membranes are more hydrophilic than polymeric membranes and are suitable for gravity filtration. Customers expressed an interest in our ceramic flat sheet membranes because they can expect compactness of equipment due to these characteristics and high membrane filtration flux. Since 2018, a pilot verification test was conducted locally, and the results were favorable. As a result, it was adopted as a filtration membrane for water purification.

The raw water for the supplied water purification equipment of the first unit is from lake water. The processing capacity is 2000 m³ per day. Fig. 7 shows the treatment flow. Fig. 8 shows the appearance of a water purification facility using ceramic flat sheet membranes. Fig. 9 shows the ceramic flat sheet membrane unit of the water purification facility. Stable filtration has continued since the start of operation. This is also a gravity filtration method using the difference in water head as in the case of Singapore. Intermittent air cleaning of the membrane contributes to the reduction of power consumption in water purification.

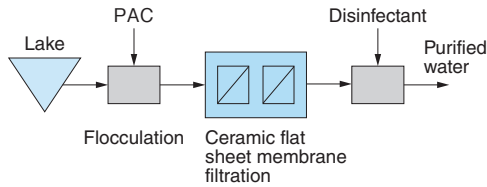


Fig. 7 Treatment Flow of Ceramic Flat Sheet Membrane Water Purification at Water Purification Plant in China

A flowchart of water purification process is shown. Raw water is taken from a lake and added with a coagulant before membrane filtration.

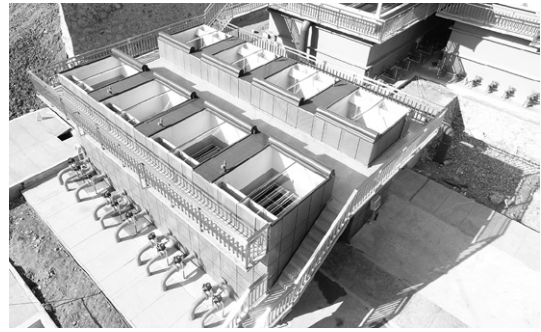


Fig. 10 Water Purification Facility with a Daily Processing Capacity of 16,000 m³ in China

An external appearance of a water purification plant (under construction) is shown. At this plant, our ceramic flat sheet membrane units will be used for a daily processing capacity of 16,000 m³.



Fig. 8 Distributed Water Purification Facility in China

A small-scale distributed water purification facility is shown. It is equipped with two filtration tanks with ceramic flat sheet membrane filtration units.

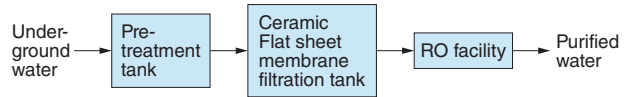


Fig. 11 Treatment Flow of Ceramic Flat Sheet Membrane Water Purification at Water Purification Plant in Saudi Arabia

This water purification plant uses raw underground water in Saudi Arabia. Its water temperature is relatively high. Our ceramic flat sheet membranes were adopted for this plant.



Fig. 9 Ceramic Flat Sheet Membrane Unit for Water Purification Facilities in China

Two flat sheet membrane units are submerged in a single membrane filtration tank. These membrane units work for membrane filtration.



Fig. 12 Ceramic Flat Sheet Membrane Unit of Water Purification Facilities in Saudi Arabia

Multiple ceramic flat sheet membrane units are used in this plant.

This track record and the expected longer service life of ceramic flat sheet membranes have been highly evaluated, and ceramic flat sheet membranes have been installed in dozens of distributed water purification plants with a daily production capacity of several thousand m³ in the same region. **Fig. 10** shows the appearance of an under-con-

struction water purification facility with a daily processing capacity of 16,000 m³.

In the future, demands for water purification plants using membrane filtration are expected to increase in China, so we will continue to promote our ceramic flat sheet membranes.

4.3 A Case in Saudi Arabia

In 2015, we delivered our ceramic flat sheet membranes to a water purification plant with a daily output of 14,000 m³ in Saudi Arabia. **Fig. 11** shows the treatment flow of this facility, **Fig. 12** shows the ceramic flat sheet membrane unit of the water

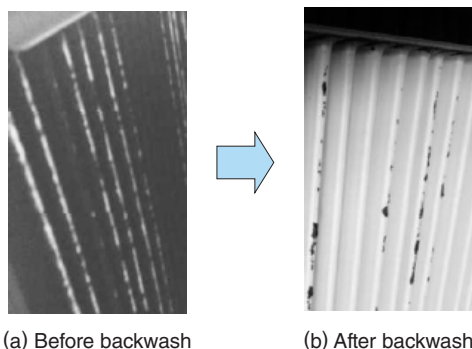


Fig. 13 Ceramic Flat Sheet Membrane Unit before and after Backwash

While membrane filtration is carried out, suspended solids are deposited on the surface of the ceramic flat sheet membranes. Most of such deposited solid is peeled off and removed by the effect of backwash to maintain filtration performance.

purification facility. **Fig. 13** shows the ceramic flat sheet membrane unit before and after backwash. The water source of this facility is groundwater, which has a high temperature and contains inorganic matter that needs to be reduced before the Reverse Osmosis (RO) treatment. To reduce the amount of inorganic matter, a water purification treatment was adopted in which chemicals were injected into the pretreatment tank and membrane filtration was performed. The temperature of the source water, however, is high and this makes it difficult to apply polymeric membranes. Our ceramic flat sheet membrane, which can be used in this temperature range, was, therefore, adopted.

Suspended solids are contained in the water to be filtered, and are deposited on the membrane surface by filtration. Since the deposits on the membrane surface can be removed by backwash, stable operation can be maintained in terms of both transmembrane pressure difference and water permeability.

5 Postscript

We introduced examples of the application of ceramic flat sheet membranes to water purification in Singapore, China, and Saudi Arabia. Applications of ceramic flat sheet membranes for water purification are gradually increasing in Japan and overseas. These membranes are contributing to the reduction of power consumption in water purification.

In the industrial wastewater field where ceramic flat sheet membranes have been introduced prior to water purification process, the number of introduction cases is also increasing, and the reuse of high-quality ceramic flat sheet membrane filtered water is in progress⁽¹⁾. We will continue to promote the introduction of our ceramic flat sheet membranes for water purification and wastewater treatment in Japan and overseas. We will promote the reduction of power consumption in water treatment, as well as the recycling and reuse of water. In this way, we will contribute in creating a decarbonized society.

Lastly, in connection with the cited projects, we would like to express our gratitude to our customers, distributors, and the engineering companies in charge of the construction.

• All product and company names mentioned in this paper are the trademarks and/or service marks of their respective owners.

《References》

- (1) Tetsufumi Watanabe: "Application of Ceramic Flat Sheet Membranes (CFMs)", Meiden Review No.176, 2019/No.2, pp.30-34
- (2) Shoichi Sameshima, Kiyotaka Wagatsuma: "Ceramic Flat Sheet Membrane (CFM)-Based Water Purification System", Meiden Review No.176, 2019/No.2, pp.2-5