Ceramic Flat Sheet Membrane (CFM)-Based Water Purification System

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Abstract

Many Japanese drinking water treatment plants now face the time for renewal or renovation of its facilities. The market, therefore, calls for the effective use of already existing facilities. The renovated facility should have a smaller footprint (space). It should promote energy efficiency and be labor saving. This means more automation in the facility and the water treatment process should be power efficient. Against this backdrop, the introduction of membrane filtration facility at water purification plant is spreading across Japan. Since the Ceramic Flat sheet Membrane (CFM) is a unique Meiden product and has an excellent chemical durability and high mechanical strength, it can provide stable filtration of (1) raw water taken from a river downstream with high level of turbidity, or (2) raw water mixed with powdered activated carbon. Our CFM received certification for use in Japanese water treatment plants. This means the performance of our membrane filtration device and its related operation control records were adequate to receive necessary technical certifications. We currently are conducting field-testing of a CFM-based water processing system. This system handles and processes raw water with high turbidity and odor substances in a unified mode where we can expect substantial energy saving.

1 Preface

In the field of drinking water treatment plants, the current issues include the improvement of purified water quality and labor-saving in the facility maintenance and management. Water purification facilities with membrane filtration system became popular since the 1990s. According to a 2018 survey conducted by the Japan Water Research Center (JWRC) to the suppliers of membrane filtration systems for drinking water treatment plants, the supply records shows the presence (or under construction) of 907 such facility sites across Japan at the end of 2017. It is anticipated that the introduction of membrane filtration facilities will increase in the future.

So far, we have reinforced our capability to perform the design, installation work and facility management of membrane filtration systems as we gained supply records at home and abroad. This paper introduces our various initiatives relating to Ceramic Flat sheet Membrane (CFM)-based water purification systems.

2 Introduction of CFM and the Certification of Membrane Module Unit for Water Purification Plant

2.1 CFM

We have developed a CFM with high-durability by drawing on our long-standing ceramic product manufacturing technology resources. Our CFM is made first by forming the ceramic material into a flat sheet shape and making its surface into a thin film. This is called the “Membrane Element” or “CFM Element.” Then, we make a CFM unit with an additional water collecting unit for membrane-filtering water. This complete unit is called the “CFM Unit.” The CFM Unit is submerged into a water tank and the raw water collected by a pump or a syphon is filtered. Fig. 1 shows a CFM observed through a Scanning Electron Microscope (SEM). Fig. 2 shows a CFM Element and Fig. 3 shows a CFM Unit CH250-1000TM100-U1DJ. Table 1 shows the specifications of the CFM Units. The features of this product are described below.

(1) Permeability is high and the pure water flux is

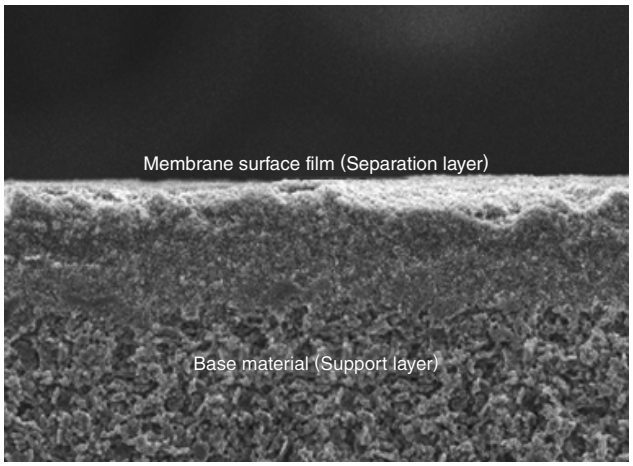


Fig. 1 CFM Observed through SEM

The formed film at CFM surface is shown. More than 90% of particles of 0.1μm in diameter can be removed.

Fig. 2 CFM Element

A film is formed on the white flat sheet surface. Water for membrane filtration is taken from the upper level water collecting pipe.

45m^3/(m^2·d).

(2) Since this product is made of ceramics, the membrane damage is rare in ordinary use. It can handle and filter the raw water mixed with activated carbon.

(3) It has a high durability against chemicals. It also withstands repeated cleansing treatment with chemicals.

(4) Since it has high enough strength to withstand high-pressure cleansing water applied to the membrane surface, coagulation floc accumulated on the membrane surface can be removed easily. The

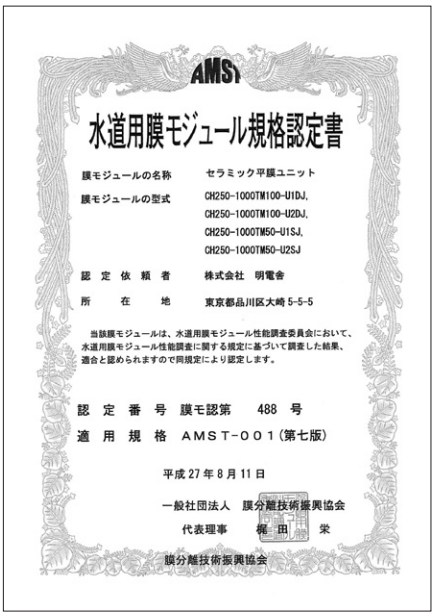
Fig. 3 CFM Unit CH250-1000TM100-U1DJ

Filtered water collected from the CFM Element is sucked up by a pump or a syphon.

Table 1 Specifications of CFM Units

Specifications of the CFM Units are shown.

Item	Specifications			
Name	CFM Unit			
Type	CH250-1000TM100-U1DJ	CH250-1000TM100-U2DJ	CH250-1000TM50-U1SJ	CH250-1000TM50-U2SJ
Membrane classification	MF			
Membrane material	Ceramic			
Membrane shape	Flat sheet membrane			
Filtration pressure method	External pressure type (Out-in)			
Membrane surface area (m^2)	100	200	25	50
Dimension (W) (mm)	2060	2116	1041	1041
Dimension (H) (mm)	1734	3280	2100	3735
Dimension (D) (mm)	720	720	364	364
Operating Water level	1300	2750	1800	3300
Nominal pore diameter	0.1μm			
Operating condition (pressure)	Max. operating pressure 60kPa, Max. permissible pressure 100kPa			
Operating condition (temperature)	Regular: 0～60℃ (No freezing) Maximum: 0～80℃ (No freezing)			



AMST

水道用膜モジュール規格認定書

膜モジュールの名称　セラミック平膜ユニット

膜モジュールの型式　CH250-1000TM100-U1DJ,
CH250-1000TM100-U2DJ,
CH250-1000TM50-U1SJ,
CH250-1000TM50-U2SJ

認定依頼者　株式会社 明電舎

所在地　東京都品川区大崎 5-5-5

当該膜モジュールは、水道用膜モジュール性能調査委員会において、水道用膜モジュール性能調査に関する規定に基づいて調査した結果、適合と認められますので同規定により認定します。

認定番号　膜モ認第　488 号

適用規格　AMST-001（第七版）

平成 27 年 8 月 11 日

一般社団法人　膜分離技術振興協会
代表理事　梶田 栄

膜分離技術振興協会

Fig. 4 Type Certification of Device on the Compliance of Membrane Module Standard for Water Treatment

This shows a certification on our CFM Unit complying with the relevant Membrane Module Standard for Water Treatment.

Transmembrane Pressure (TMP) can be recovered without replacing the membranes or without chemical cleaning.

(5) It can also be applicable to a Membrane Bioreactor (MBR) in sewage treatment plant. Direct filtration of raw water with high turbidity over 1000 degrees is possible.

2.2 Membrane Module Certification

The membrane module to be used in drinking water treatment plant is required to conform to the related facility standard stipulated by the Water Utility Law in Japan. The Association of Membrane Separation Technology, Japan (AMST), established “AMST-001: Standard of MF and UF modules for Drinking Water Use.” The AMST is a third-party certification body and provides independent confirmation if a membrane module for water purification plant meets the facility standard requirements. In August 2015, our CFM Unit received a certification from the AMST to confirm the compliance to the AMST-001 Standard. **Fig. 4** shows a copy of the type certification on the compliance to the said Standard.

3 Technical Certification for Membrane Filtration Units

The JWRC engages in the technical research on water purification facilities and aims to help the promotion and penetration of such facilities across Japan. The JWRC is a third-party certification body and provides independent confirmation if a system for water purification facilities meets the facility standard requirements. This certification is made based on the facility specifications and various factors such as design, operation and maintenance. The JWRC also evaluates the field-test data obtained under the condition of continuous operation for more than half year. Many firms relating to membrane filtration units for water treatment plants received their technical certification from the JWRC. We conducted a field test at a water source where water temperature lowers to nearly 0℃ in the winter and received our technical certification in September 2017. **Fig. 5** shows an example of a field test under low water temperature conditions in the winter.

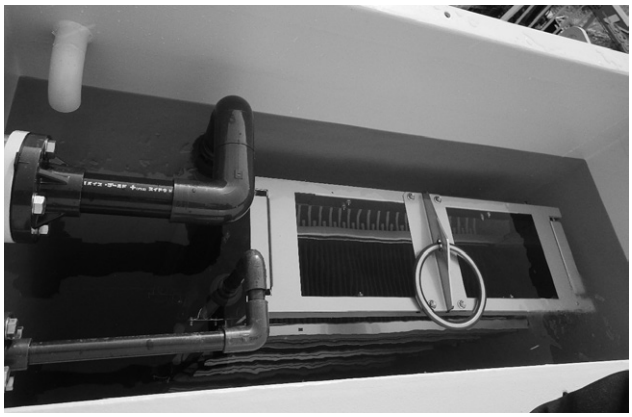


Fig. 5 Example of Field Test under Low Water Temperature Conditions in the Winter

This shows a water treatment device under field test. This device uses our CFM Unit CH250-1000TM50-U1SJ.

In addition to the CFM-based membrane filtration system, we received different technical certifications on membrane module units with housing and immersion type membrane modules supplied by other firms. For this reason, we can offer various types of membrane filtration systems to fit the needs of our customers, or the conditions of water resources. We supplied the above-mentioned certified system to the Akazawa Water Purification Plant (MF membrane, Daily capacity 500m^3/d) and the Furudate Water Purification Plant (MF membrane, Daily capacity 4000m^3/d) in Shiwa-cho, Iwate Prefecture (this plant is currently owned by Iwate Central Water Supply Authority). **Table 2** shows lists of our JWRC-certified system for drinking water treatment plant.

Table 2 Lists of Our JWRC-Certified System for Drinking Water Treatment Plant

"Joint applicants" on the column of certified applicant means the application was jointly made by several parties including us and the application was subsequently approved.

Certified applicant	Membrane type	Certification registration number	Date of receiving certification
Joint applicants	Immersion type MF membrane	No.1068	30 March 2006
MEIDEN	MF membrane with housing	No.10001	30 January 2008
MEIDEN	MF membrane with housing	No.10001-(1)	13 March 2009
MEIDEN	MF membrane with housing	No.10008	29 March 2010
Joint applicants	Immersion type MF membrane	No.10012	21 April 2012
MEIDEN	UF membrane with housing	No.10011	25 January 2012
MEIDEN	MF membrane with housing	No.10008-(1)	27 February 2012
Joint applicants	Immersion type MF membrane	No.10025	25 September 2017

Fig. 6 Example of Field-Testing for Immersion Type Membrane Modules in Membrane Separation Tank (SS = 2700mg/L)

Membrane filtration is performed using the effect of the water level difference between the water level of the membrane separation tank and that of the purified water tank. At this separation tank, air agitation is applied to the raw water mixed with a coagulant.

4 Sample Cases of Our CFM Devices in Operation

In order to reduce renewal costs for water purification plants, the market calls for the effective use of already existing facilities. The immersion type membrane filtering devices can be effectively used for concrete sedimentation tanks and concrete filtration basins. Both reservoir facilities have a long operation life. In most cases, the membrane filtration method tends to use pumping power. A new trend gaining popularity is to use the water level difference between the inlet height level and outlet height level in the membrane filtration processes. This process does not need pumping power. This latter case can save substantial energy and could lower operation costs.

Regarding the quality of raw water, to secure good water quality, water utilities tend to get raw water situated upstream of a river whose water quality is relatively clean. It is expected, however, that from now on, water utilities will increasing get raw water from the downstream river, and high turbidity condition may be continued for a long time. There is a concern of an increase of organic substances or odor substances. To meet such cases, we must introduce the following combined processes in water treatment, (1) pretreatment as flocculation and (2) filtration combined with powdered activated carbon. In order to purify raw water containing high turbidity and odor substances at downstream river, we are conducting field testing of the membrane filtration device utilizing the inlet and outlet water level difference to realize more energy saving. Fig. 6 shows an example of the field-testing for the immersion type membrane modules in membrane separation tank "Suspended Solids 'SS' = 2700mg/L."

5 Postscript

This paper introduced the features of CFM-based membrane filtration devices which are our unique product. We also show our initiatives to promote the introduction of such devices for water supply authorities in Japan. Our CFM is a product that can address the issues facing water utilities. They are addressing water treatment plants for the time of facility renovation or renewal. We will continue our field-testing to verify our processing method.