

Powder Activated Carbon Treatment Membrane Bioreactor (PACT MBR) Using Ceramic Flat Sheet Membrane (CFM)

Keywords Water processing membrane, Water recycling, Ceramic, Oil and gas industry

Abstract

Ceramic Flat sheet Membrane (CFM) elements are used as water processing membranes having favorable features such as high durability and long operational life. For these reasons, the CFM has been applied in water treatment systems of the Power Activated Carbon Treatment Membrane Bioreactor (PACT MBR) by Siemens Corporation. This system is used to treat the oil containing wastewater discharged from petroleum refineries and petrochemical plants.

The PACT MBR is capable for simultaneous treatment of activated sludge, powdered activated carbon via filtration in a single tank. This compact system reduces approximately 50% tank installation footprint comparing with conventional treatment. The powdered activated carbon can adsorb decomposable organic matters and oily substances. In addition, it can remove the membrane foulants (substances cause membrane blockade) from the membrane surface so that stable filtration treatment can be carried out.

In order to determine CFM applicability in the PACT MBR, abrasion test was conducted for 36 months using CFM and powdered activated carbon in an actual system. Compared with unused items, it has been verified that no damage is perceived on the membrane surface due to abrasion and we concluded that a long time of use is possible.

1 Preface

The Ceramic Flat sheet Membrane (CFM) is a water treatment membrane with high physical and chemical durability. We explain the CFM application to Powder Activated Carbon Treatment Membrane Bioreactor (PACT MBR) system for the treatment of oil containing wastewater, discharged from refineries and petrochemical plants.

2 Characteristics of CFM

The flat-shaped CFM element is composed of inorganic alumina material, and used for water filtration treatment. Fig. 1 shows an external appearance of the CFM element. The alumina material is very robust, having very high physical and chemical durability. Due to these features, the CFM also provides excellent resistance to abrasion and the industrial wastewater which contains oils, chemical



Fig. 1 CFM

An external appearance of the CFM element is shown.

pollutants, suspended solids, and heavy metals. The CFM provides excellent long-term filtration characteristics in the presence of these contaminants, whereas conventional polymeric membranes would likely be subject to increased fouling rate and possible membrane abrasion from contact with grit-

Table 1 Specifications of CFM Element

The product specifications of the CFM element are shown.

Item	Specifications
Membrane type	Microfiltration, flat sheet
Material	Alumina
Nominal pore size	0.1 μm
External dimensions	W281 × H1046 × T12mm
Mass (dry)	1.8kg
Membrane area	0.5m ²

Table 2 Specifications of CFM Unit

The specifications of the CFM element to be used at an actual water processing site are shown.

Item	Specifications	
Model	CH250-1000TM100-U1DJ	CH250-1000TM100-U2DJ
Number of membranes	200 elements	400 elements
Membrane area	100m ²	200m ²
External dimensions	W2060 × H1734 × D720mm	W2116 × H3280 × D720mm
Mass (dry)	610kg	1160kg

like suspended solids.

Table 1 shows the specifications of the CFM. The nominal pore size is 0.1 μm and it is classified as a microfiltration membrane. The CFM is installed in modules each known as a “CFM Unit.” There are two standard units and Table 2 shows their specifications. These available units of 200 membranes and 400 membranes can be selected according to the water depth of the unit installation tank.

The CFM elements have been widely sold in the overseas mainly in Singapore and China. In Singapore, the durability and treatment capacity of CFM was evaluated, and full-scale treatment systems have been successfully operated. In Changi Water Reclamation Center (operation started since January 2017 and treatment capacity of 15,000m³/d) for public sewerage treatment and in Chestnut Avenue Water Treatment Plant (operation started since June 2017 and treatment capacity of 36,400m³/d) for water purification, are the largest plants for the CFM filtration operation in the world.

3 CFM Application in PACT MBR

In harsh industrial wastewater oils, and grit-like suspended solids, polymeric membranes treatment performance is reduced. The CFM is especially

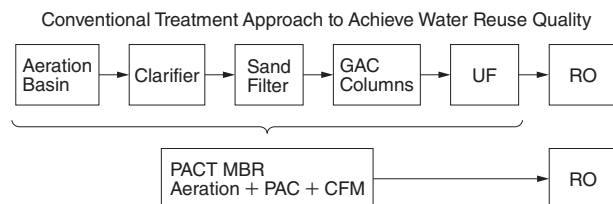


Fig. 2 Comparison of Conventional Oil-Containing Wastewater Treatment Process and PACT MBR Treatment System

The PACT MBR Treatment System has been verified to be a very compact system compared with conventional oil-contained wastewater treatment processes.

effective for industrial wastewater treatment, because of its high durability and abrasion-resistant features appropriate stable treatment is possible for a long period operation to produce high quality water. Here is described PACT MBR treatment system as an example.

The PACT MBR is a technology developed by Siemens Water Solutions to produce reusable quality wastewater discharged from refineries and petrochemical plants.

Fig. 2 shows the flow comparison between PACT MBR treatment system and conventional treatment process. Compared with the conventional treatment processes like combining activated sludge treatment, sand filtration, Granular Activated Carbon (GAC) column, Ultrafiltration (UF) membrane and Reverse Osmosis (RO) membrane treatment, the PACT MBR treatment system drastically reduces the treatment steps. Since PACT MBR can process activated sludge treatment, the combination of powdered activated carbon treatment and ceramic membrane treatment in one tank reduces approximately 50% footprint than that of the conventional treatment.

PACT MBR also prevents membrane fouling as below.

- (1) Activated carbon adsorbs organic matter and oil that causes bio-fouling
- (2) Activated carbon controls the pollutants contact on the membrane surface

However the polymeric membranes have adverse effect of abrasion and breakage compared with the CFM, improved cleaning method is expected from CFM. When the abrasion test with powdered activated carbon and CFM was performed for 36 months, the same thickness variation encountered with virgin membrane surface. It indicated no adverse impacts from abrasion of the activated car-

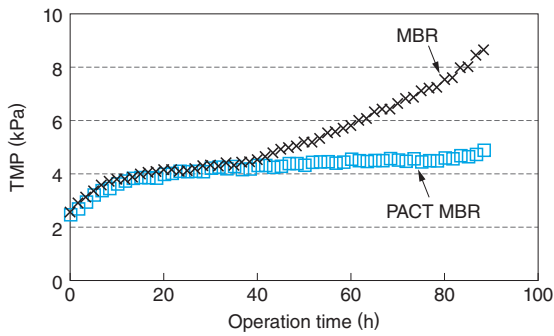


Fig. 3 Comparison of TMP Difference between MBR and PACT MBR

For the comparison of transmembrane pressure that is an index of membrane clogging, the same sludge was filtered through the MBR and the PACT MBR. The graphs indicate that the PACT MBR performs more efficient suppression of transmembrane pressure and stabilized filtration is achieved as a result.

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Table 3 Comparison of Treated Water Quality of MBR and PACT MBR

The treated water quality from the PACT MBR is more superb as compared with conventional MBR is shown.

Test results	Refinery wastewater compounds	MBR Remaining Filtrate removal	PACT MBR Remaining Filtrate removal
BOD	~400mg/L	<5mg/L 99%	<5mg/L 99%
COD	~750mg/L	151mg/L 81%	46mg/L 92%
TOC	~200mg/L	27mg/L 86%	11mg/L 94%

bon on the CFM. It was confirmed that it can be used for a long time due to its high durability of CFM. PACT MBR system reduces frequent of Clean-In-Place (CIP) cleaning cycles and improves greater membrane flux.

To evaluate PACT MBR treatment performance, diesel oil was added to activated sludge collected from a sewage treatment plant and the Transmembrane Pressure (TMP) was compared between conventional MBR and PACT MBR. Fig. 3 shows the increase of TMP. It is confirmed that the increase of TMP can be suppressed in PACT MBR due to the effect of powdered activated carbon.

Table 3 shows the water quality comparison between MBR only and PACT MBR during refinery

wastewater treatment. Although the removal rate of Biochemical Oxygen Demand (BOD) of treated water was comparable, Chemical Oxygen Demand (COD) and Total Organic Carbon (TOC) removal occurred higher for PACT MBR, which revealed higher removal rate.

4 Features of PACT MBR Processing System

The features of PACT MBR processing system are summarized below.

- (1) Improves organics removal, including removal of recalcitrant COD, especially COD adsorbed onto the surface of the activated carbon.
- (2) Reduces biological fouling of CFM, reduces membrane cleaning cycles and improve membrane flux
- (3) Reduces RO membrane fouling in reuse applications, saving membrane cleaning and replacement costs.
- (4) Increases biological process stability that is much less prone to upsets and their consequent process disruptions versus conventional biological processes.
- (5) Reduces effluent toxicity caused by residual, non-biodegradable organics and heavy metals.
- (6) Reduces the construction cost and installation area by reducing sedimentation tanks, GAC columns, etc. from conventional wastewater treatment process.

5 Postscript

The PACT MBR treatment system is a simplified, cost effective, next generation alternative to conventional oily wastewater treatment processes. Going forward, we are planning to introduce and apply this especial feature's PACT MBR system in oil drilling, petroleum refining and petrochemical fields.

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