Scientific Paper on

Using of ceramic compared with polymeric membranes filters in drinking water, urban and industrial wastewater filtration

MARCH 2014

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استخدام فلاتر أغشية السيراميك مقارنةً بفلاتر أغشية البوليمر في تنقية مياه الشرب ومعالجة مياه الصرف الصحي والصناعي

مارس ٢٠١٤

إعداد

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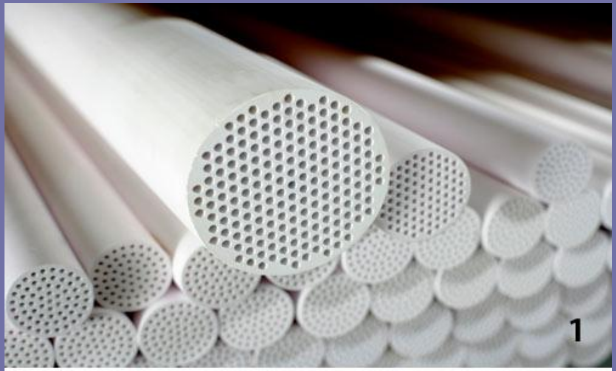
objectives

- Introduction to filtration.
- Membrane separation
- Polymeric membranes.
- Ceramic membranes.
  - Structure of ceramic membranes.
  - Operation mode of Ceramic Membrane.
  - Applications of Ceramic Membrane.
  - Ceramic membranes market.
  - Future of Ceramic Membrane.
- Ceramic VS Polymeric Membrane.
- CAPEX and OPEX.
- Ceramic Membrane disadvantages.
- Conclusion.
- Sources & References.



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Introduction to filtration

The purpose of filtration : is to remove suspended particles from water by passing the water through a medium. As the water passes through the filter, floc and impurities get stuck in the medium and the clean water goes through.

Filtration is usually the final step in the solids removal process which began with coagulation and advanced through flocculation and sedimentation.

In the filter, up to 99.5% of the suspended solids in the water can be removed, including minerals, floc, and microorganisms.

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Introduction to filtration

why we remove turbidity : Although turbidity is not harmful on its own, turbid water is difficult to disinfect for a variety of reasons.

Microorganisms growing on the suspended particles may be hard to kill using disinfection while the particles themselves may chemically react with chlorine, making it difficult to maintain a chlorine residual in the distribution system. Turbidity can also cause deposits in the distribution system that create tastes, odors, and bacterial growths.

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Introduction to filtration

Polymer Aids, may sometimes be added to the influent water. These chemicals improve the quality of the effluent water by helping the floc get caught in the filter.

Polymer aids come in two main types. Moderate molecular weight cationic polymers (DADMA) are added ahead of flocculation to strengthen the floc while relatively high molecular weight nonionic polymers (polyacrylamides) are added just before filtration to aid in floc removal.

Polymer aids can be troublesome in some respects. In addition, extended use of polymer aids may gum up the filters. As a result, polymer aids are often used like coagulant aids - in extreme situations to improve the water quality for a short time.

Introduction to filtration

Mechanisms of Filtration

Straining, passing the water through a filter in which the pores are smaller than the particles to be removed. This is the most intuitive mechanism of filtration, like sand filters , membrane filters, disk filters.

Adsorption, in many cases the most important mechanism of filtration, is adsorption. **Adsorption** is the gathering of gas, liquid, or dissolved solids onto the surface of another material.

Absorption, the soaking up of one substance into the body of another substance. Absorption should be a very familiar concept - sponges absorb water.

Membrane Separation

A membrane is a semi permeable, or selectively permeable, barrier that allows some molecules or ions to cross it while hindering the passage of others.

In membrane separation a portion of fluid known as permeate (or filtrate) passes through the membrane, while other constituents are rejected by the membrane and retained in the retentate (or concentrate) stream.

Membranes are fabricated from a variety of materials, including both organic and inorganic materials such as metals, polymers and ceramics.

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polymeric Membrane Filters

Polymeric membranes typically formed by coating a thin polymer layer on a porous backing or support to create a combination that provides high permeability, selectivity, mechanical strength, and chemical stability.

The most commonly used polymers for commercial membranes are :

Polyamide, Cellulose acetate, Polysulfone,

-Polyether sulfone, Polyvinylidene fluoride

-Polyimide, Polyetherimide

-Polyethylene, polypropylene

Introduction to Ceramic Membrane Filters

The ceramic membranes are often formed into an asymmetric, multi-channel element. These elements are grouped together in housings, and these membrane modules can withstand high temperatures extreme acidity or alkalinity and high operating pressures, making them suitable for many applications where polymeric and other inorganic membranes cannot be used. Several membrane pore sizes are available to suit specific filtration needs covering the micro, ultra, and nanofiltration ranges (from 5 mm down to 1000 Daltons)

* Molecule of water is equal to 18 Daltons

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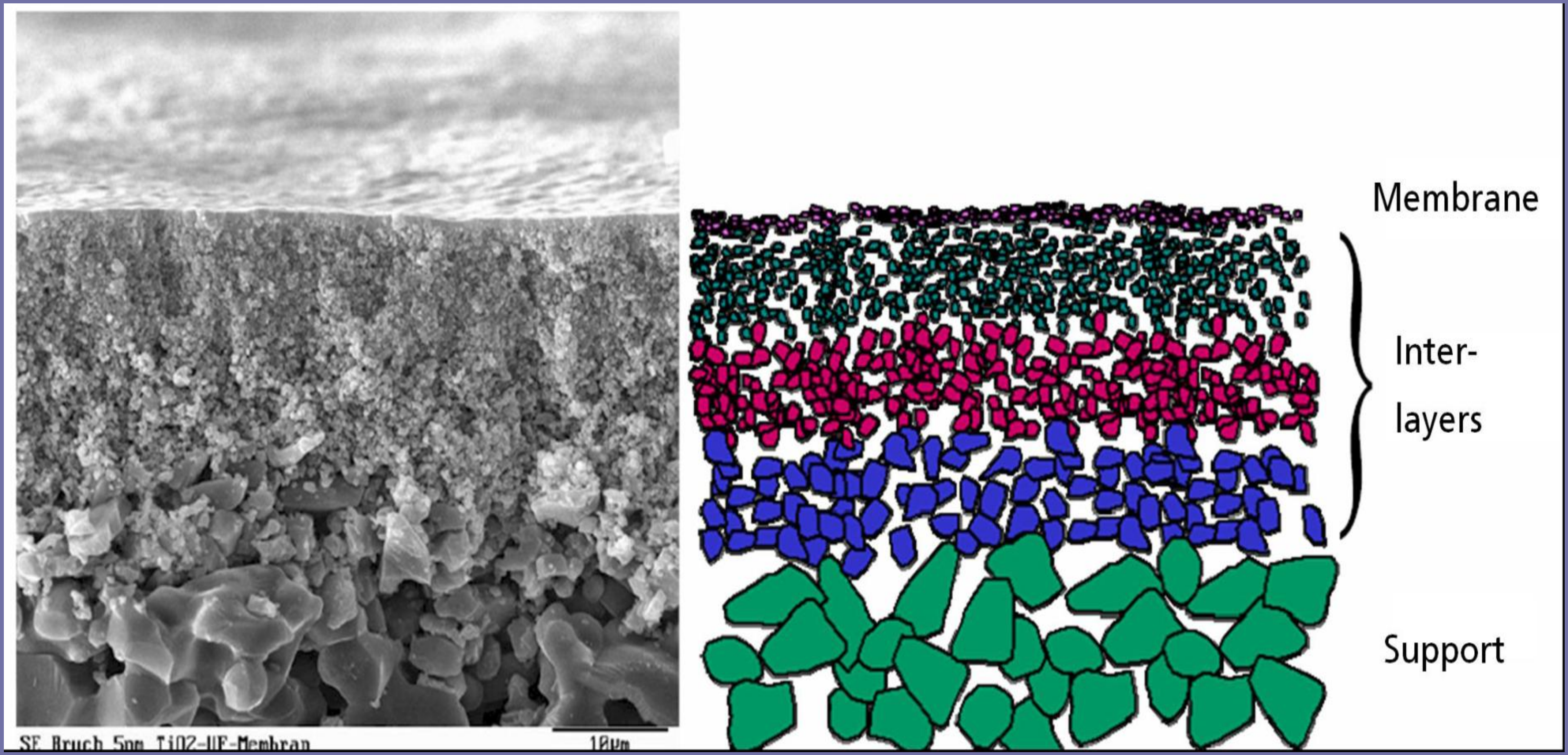
Structure of ceramic membranes



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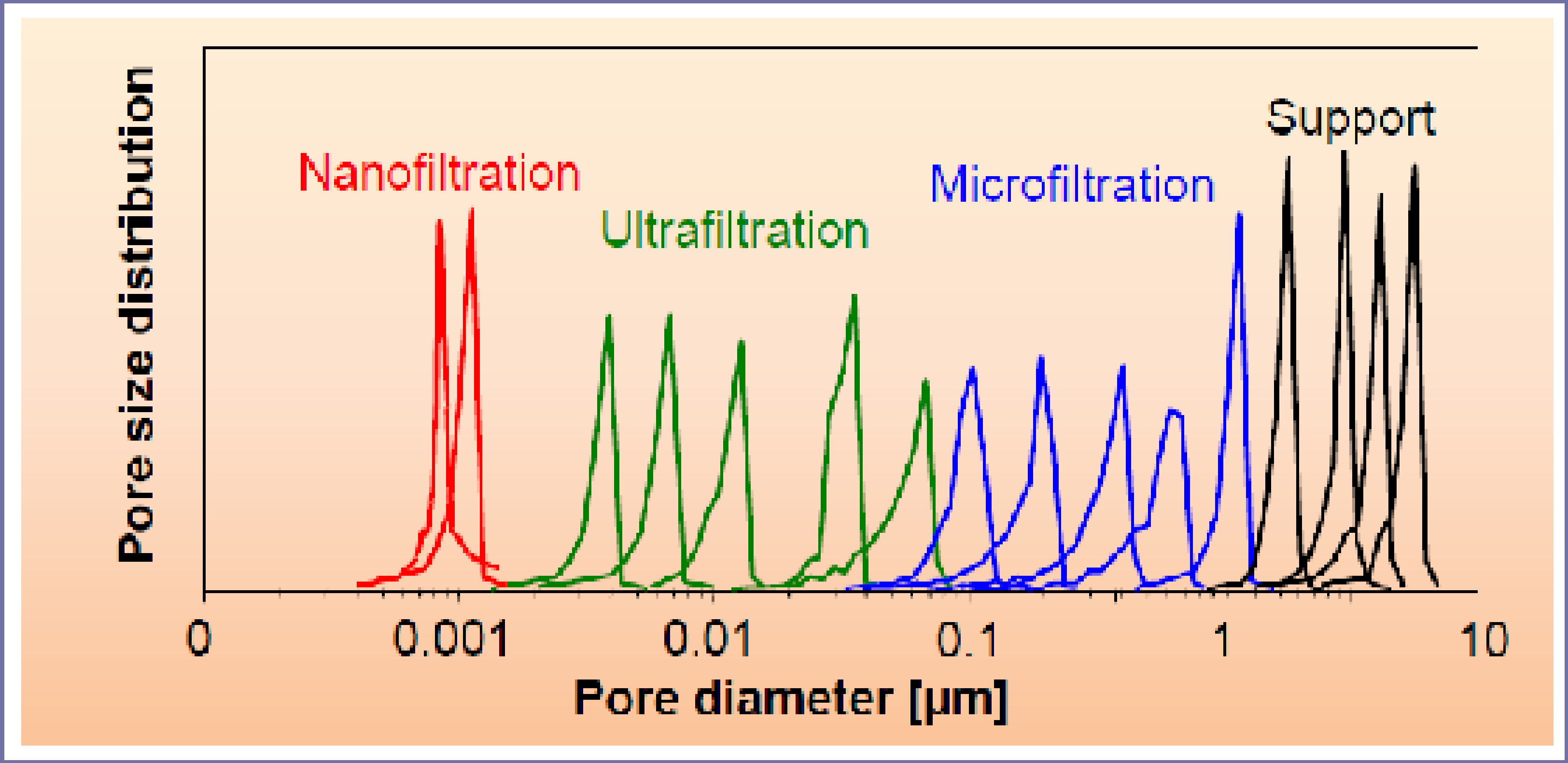
Pore sizes of ceramic membranes



Materials of Ceramic Membrane

The most common membranes are made of Al, Si, Ti or Zr (Zirconium) oxides,
In some less frequent cases, Sn (Stannum) or Hf (Hafnium) are used as base elements.
Each oxide has a different surface charge in solution.

Other membranes can be composed of mixed oxides of two of the previous elements, or are established by some additional compounds present in minor concentration

Operation mode of Ceramic Membrane

Ceramic membranes are operated in the cross flow filtration mode. This mode has the benefit of maintaining a high filtration rate for membrane filters compared with the direct flow filtration mode of conventional filters.

Cross flow filtration is a continuous process in which the feed stream flows parallel (tangential) to the membrane filtration surface and generates two outgoing streams.

A small fraction of feed, called permeate or filtrate, separates out as purified liquid passing through the membrane.

The remaining fraction of feed, called retentate or concentrate, contains particles rejected by the membrane.

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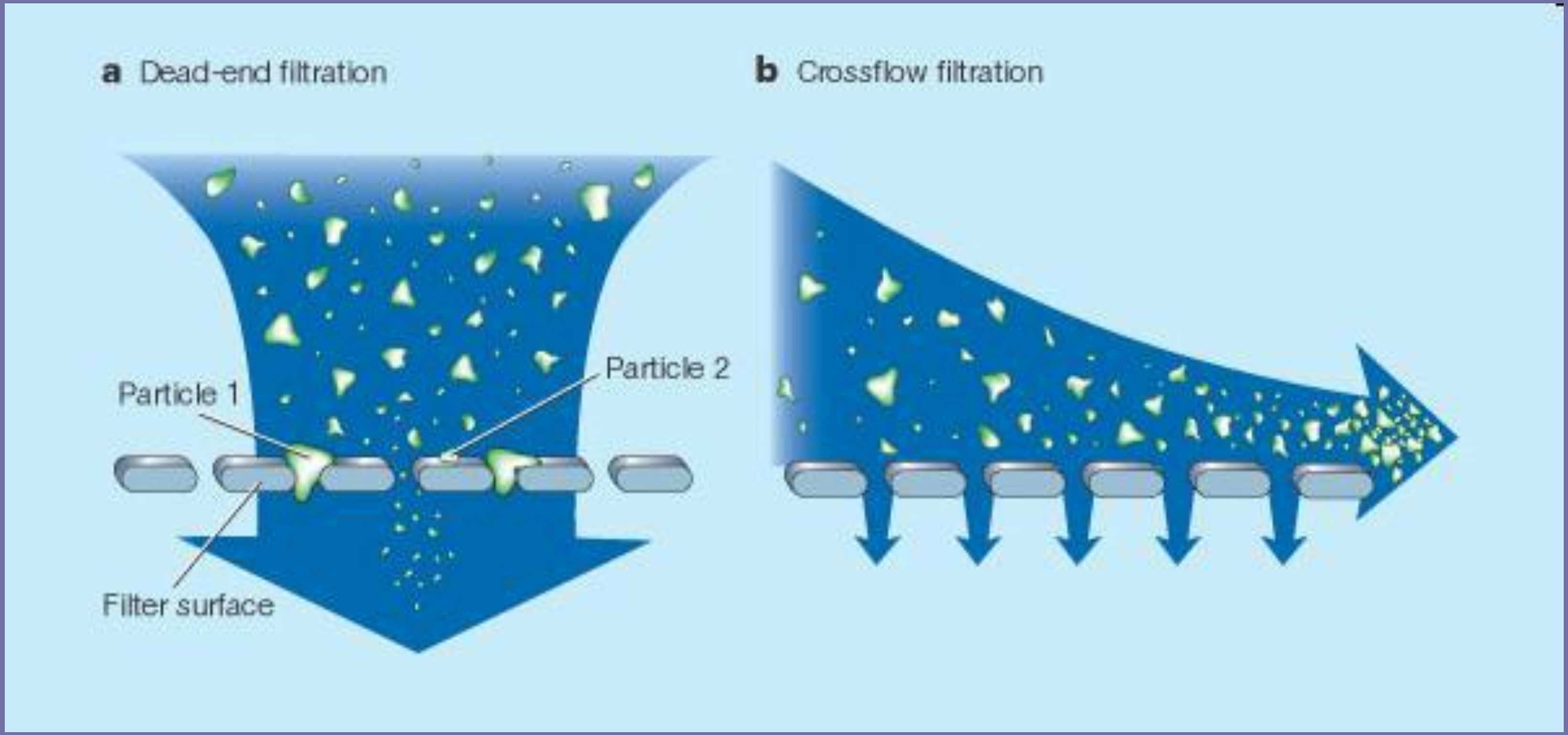
Operation mode of Ceramic Membrane



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Types of Ceramic Membrane

Flat sheet

Hollow fiber

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Ceramic Membrane Manufacturers*

	Product Line(s)	Filtration Range	Support Materials	Membrane Materials	Channel Configuration
Pall	Membralox® Schumasiv®	5nm to 0.2 µm	Al_2O_3	Al_2O_3 (MF) ZrO_2 and TiO_2 (UF)	Hexagonal and round
Corning	CerCor®	5nm to 0.2 µm	Mullite ($3Al_2O_3 \cdot 2SiO_2$)	ZrO_2 (MF) TiO_2 (UF)	Square and round
TAMI	Ceram Inside®	0.02 µm to 1.4µm	ATZ	ZrO_2 (MF) TiO_2 (UF)	Flower shaped
Atech	Atech	0.01 µm to 1.2 µm	Al_2O_3	Al_2O_3 (MF) ZrO_2 and TiO_2 (UF)	Single or multiple round
Orelis	Kerasep™	5 kDa to 0.8 µm	Al_2O_3	ZrO_2 and TiO_2	Single or multiple round

Applications of Ceramic Membrane

Ceramic membranes are used in all applications of water filtration

1- surface water filtration
2- ground water filtration
3- sea water pretreatment
4- sewage filtration
5- Industrial wastewater filtration

Applications of Ceramic Membrane

Ceramic membranes are increasingly being used in water purification and wastewater filtration and specially in industrial applications because The membrane modules can withstand elevated temperatures, extremes of pH (0 to 14), and high operating pressures up to 10 bar (145 psi) without concern for membrane compaction, delamination or swelling,

This makes these membranes suitable for many applications such as biotechnology and pharmaceutical, dairy, food and beverage, as well as chemical and petrochemical, microelectronics, metal finishing, and power generation where polymeric and other inorganic membranes cannot be used.

Applications of Ceramic Membrane

Ceramic membranes are used for fermentation broth clarification at numerous installations worldwide, successfully competing with other technologies such as polymeric membranes, vacuum filtration and centrifugation.

in many chemical process applications there is the need to treat not only the waste streams, but also to recover and reuse chemicals. Ceramic membranes can be applied for this purpose, i.e. filtration of chemical solvents, dye and pigment wastewater from dye processing and coloring plants and highly variable wastewater containing detergents, polymers and organic solvents.

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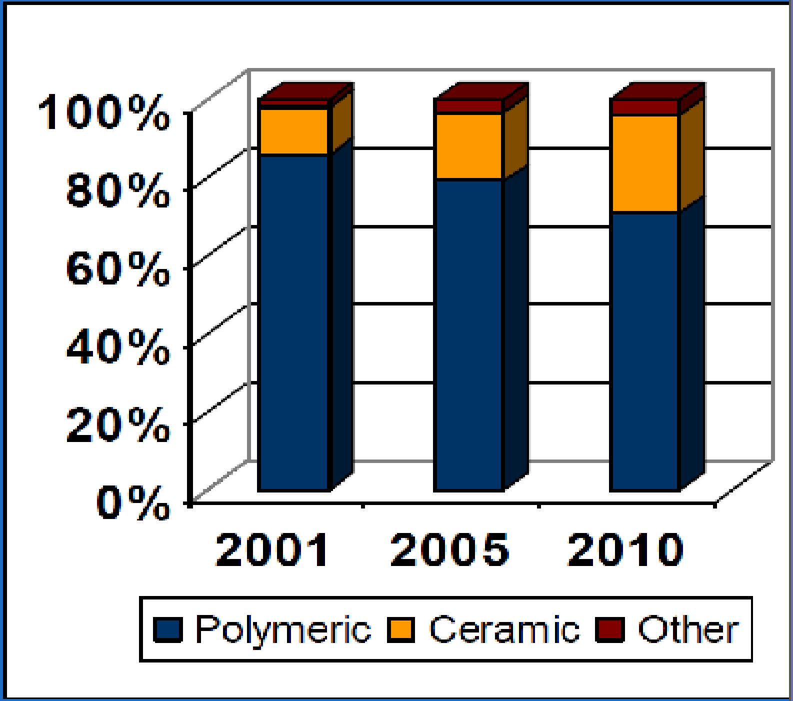
Membrane Filtration Market

The ceramic membrane market share is expected to grow in future years!

Advances in materials, configuration, and operational experience will make ceramic membranes more widely used.



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Future of Ceramic Membrane

Ceramic membranes in conventional design, in which multiple elements in stainless steel housings are employed, have a considerable higher price compared to conventional modules with membranes based on polymers.

However, advanced product lines such as monolithic ceramic membrane modules characterized by a much higher membrane surface per module could allow a cost effective solution in the future.

Ceramic VS Polymeric Membrane Filters

The use of Ceramic Membrane Filters can extensively reduce the number of pretreatment steps required to remove high amounts of oil , fats and grease (FOG) contents because its high ability to remove big amounts of fats with out affecting its performance via heavy organic fouling.

The Ceramic Membrane Filters treat wastewater at high temperature effectively compared with polymeric Membrane Filters at 75 °c.

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Ceramic VS Polymeric Membrane Filters

The Ceramic Membrane Filters have the ability to break stable fatty acid methyl ester (FAME) with surfactant emulsion without the need for addition of emulsion-breaking chemicals.

The Ceramic Membrane Filters have more options to back wash such as:

high pressure back pulse (up to seven bars at time less than one second) this can not be done with polymeric Membrane Filters as the burst pressure of it is less than seven bars.

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Ceramic VS Polymeric Membrane Filters

In event of a need for down-time for light fouling the stronger or more concentrated oxidizing agents can be used in cleaning in-place (CIP) with Ceramic Membrane Filters but can not be used with polymeric Membrane Filters and peroxide cleans are no problem with Ceramic Membrane Filters but can not be used with polymeric Membrane Filters.

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Ceramic VS Polymeric Membrane Filters

Steam (CIP) is used with Ceramic Membrane Filters but can not be used with polymeric Membrane Filters when chemicals is insufficient or there is a need to sterilize as well as clean a membrane.

The last resort to regenerate the ceramic membrane would be to subject it to high heat treatment in air atmosphere at 400 degrees to completely combust off the accumulated organic foulants.

Ceramic VS Polymeric Membrane Filters

The high porosity and hydrophilic surface of ceramic membranes allows an operation with high filtration fluxes. To ensure a given plant capacity the membrane surface area will be smaller compared to polymer membranes

Another advantage of ceramic membranes is seen in their high mechanical stability

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CAPEX and OPEX

In terms of CAPEX Ceramic Membrane Filters is approximately five times more costly than polymeric Membrane Filters however their operating life spans are also in excess of five times that of polymeric Membrane Filters.

In terms of OPEX the reduction in operating and maintenance cost by switching to Ceramic Membrane Filters can be up to 50 %.

Ceramic Membrane Disadvantages

- The main disadvantage for ceramic membranes is the high capital cost.
- high weight which require special care while installation.
-The brittleness of ceramic membranes regarded as a disadvantage, Different thermal expansion of the membrane material and the housing require special sealing techniques.
- The direct treatment of surface water with ceramic membranes without usage of flocculants showed the influence of steric and charge mechanisms on removal of particles in the size range of viruses. Size exclusion was found to be a major, but not the only, mechanism which influences the efficiency of phages removal by filtration with ceramic membranes.

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Conclusion

- Ceramic membranes used in all applications of water and wastewater filtering and seawater desalination.
- Ceramic membranes are considered as resistant to mechanical, chemical and thermal stress.
- Ceramic membranes more efficient in operation because it has more options to back wash.
- Ceramic membranes are used mainly for industrial applications.
-The use of ceramic membranes in drinking water supplies is limited due to the relatively high investment costs however the high capital cost is generally compensated for by a long service life.
- We can begin to use Ceramic membranes in small scales for wastewater applications.

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Sources & References

- www.lenntech.com, Rishi Sondhi, Ramesh Bhave and Gary Jung, 'Applications and benefits of ceramic membranes', Membrane Technology November 2003
- www.siemens.com, Panglisch, S. Advances in Ceramic Membrane Filtration. Proc. Of AWWA Membrane Technology Conference, Memphis,TN (03/17/2009).
- www.usbr.gov/research/AWT/ Katie Benko, Bureau of Reclamation Jörg Drewes, Colorado School of Mines
- http://water.me.vccs.edu
- http://www.tzw.de/
- http://www.aiche.org/cep/