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Application of Ceramic Membrane in Water and Wastewater Treatment

Feng LIN[1] , Shoubin ZHANG[2*], Guoqiang MA[2] , Liping QIU[2], Huajun SUN[3]

[1] Rizhao Municipal Drainage Administration, NO.229, Zaozhuang Road.,Rizhao 276800, P.R.China
[2] School of Civil Engineering & Architecture, University of Jinan, NO.336, Nanxinzhuang West Road.,Jinan 250022, P.R.China
[3] Advanced Ceramic Institute, Zibo New & Hi-tech Industrial Development Zone, Zibo 255000, P.R.China

Abstract. In recent years, ceramic membranes have been widely used in the field of water and wastewater treatment by virtue of their advantages over conventional water treatment technologies. In this article, definition, classification and characteristics of ceramic membrane were introduced firstly. And then the application of ceramic membrane technology used in various fields of water and wastewater treatment was highlighted. Finally, several opinions on the development prospects of ceramic membrane technology were raised.

1 Introduction

With the rapid development of the economy and the continuous growth of the population, the shortage of water resources has become more and more serious. In some fields, the traditional water and wastewater treatment technology has not been able to meet the requirement of current water and wastewater treatment. Therefore, a series of novel water and wastewater treatment technologies have emerged. As a new membrane separation technology, ceramic membranes have promoted ceramic membrane technology with good chemical stability, high mechanical strength and high temperature resistance in water and wastewater treatment. After the 1990s, the market share of ceramic membrane has reached about 80% [1]. Based on the advantages of ceramic membranes compared to traditional technologies, the application of ceramic membranes in various fields of water and wastewater treatment was reviewed and some proposals for the further application of ceramic membrane was made.

2 Overview of ceramic membrane

2.1 Definition of ceramic membrane

The ceramic membrane is an inorganic separation membrane made of ceramic material with separation function. It is a product obtained by uniformly mixing additives of inorganic raw materials after reaction molding, and calcination at high temperature. The interior contains a lot of pores, porosity is greater than 30% and the average pore size usually 1~10μm [2].

2.2 Classification of ceramic membrane

Different classification methods, ceramic membrane can be divided into different types. According to the different membrane modules, they can be divided into flat membranes, roll membranes, hollow fiber membranes, and tubular membranes; they are divided into terminal filtration and cross-flow filtration according to the filtration method; the membrane pore size can be divided into microfiltration membranes, ultrafiltration membranes and nanofiltration membranes.

2.3 Advantages and disadvantages of ceramic membrane

Compared with the organic membranes that are currently used more industrially, ceramic membranes have the following advantages [3-4]:

1) Good chemical stability, acid and alkali resistance and organic solvents, good oxidation resistance.

2) High mechanical strength, no deformation under high pressure or large pressure difference, abrasion resistance, erosion resistance, high pressure back pressure can be used to regenerate the film.

3) It has strong anti-microbial ability and good antibacterial effect. It is suitable for medical and biological engineering.

4) High temperature resistance. Generally it can be operated at 400°C. The maximum operating temperature is up to 800°C.

5) The pore size distribution is narrow and the separation efficiency is high.

6) Non-toxic, suitable for food and drug treatment.

The disadvantages of ceramic membranes are the high cost, incompatibility with alkali, and the brittleness of ceramic materials, which brings certain difficulties to the forming process and assembly of the membrane.

3 Application of ceramic membrane in municipal water and wastewater treatment

3.1 Application in municipal water treatment

In the water treatment process, ceramic membranes are generally used for high value-added products, and their cost is higher than that of conventional processes. Due to the fact that no chemical agents are added and the quality of the effluent water quality is stable, people gradually pay attention to it. In recent years, household ceramic membrane water purifiers are also emerging. They can retain beneficial minerals in water during filtration, remove bacteria, rust, heavy metal ions, etc., and do not produce secondary pollution. They can be directly consumed and have broad market prospects.

3.2 Application in domestic sewage treatment

Compared with industrial wastewater, domestic sewage has a low degree of pollution, but it has a large amount of water. If it is handled improperly, it will cause serious pollution to the water body. Therefore, it is necessary to properly treat the urban sewage. Figure 1 is a typical process of domestic sewage treatment using ceramic membrane technology.

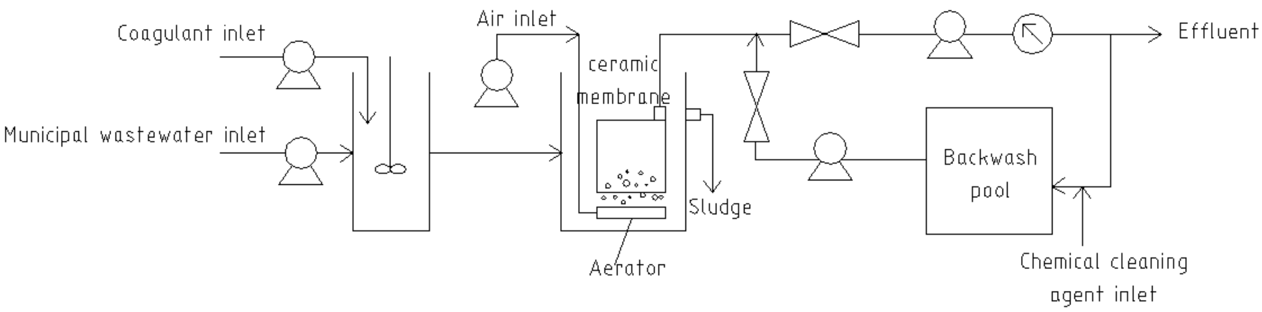

Figure 1 Process Flowchart of Typical Domestic Sewage Treatment Using Ceramic Membrane Technology

Xing Chuanhong et al[5]. used inorganic zirconium oxide membrane as the core membrane module of IMBR to treat domestic sewage. When HRT was 5h, membrane flux was 75-150L/(m^2.h), and membrane surface velocity was 4m/s, COD was The removal rates of ammonia, nitrogen, and SS reached 96%, 95%, and 100%, respectively, and the quality of treated effluent up to the standards for miscellaneous water quality.

Liu Jun et al[6] used inorganic ceramic membranes to treat domestic sewage, examined the decontamination capacity of different cleaning agents for membrane tubes, and the results showed that membrane fouling was mainly caused by biological, organic matter, colloidal substances, etc., using 0.5% NaOH and 7.5% H_2O_2 have a good cleaning effect on the membrane tube.

4 Application of ceramic membrane in industrial wastewater treatment

4.1 Application in oily wastewater treatment

Oily wastewater mainly comes from emulsion wastewater, oil field produced water, cleaning fluids, food industry oily wastewater and so on. Oily wastewater is difficult to degrade, emulsify easily, and has serious pollution. Conventional methods are difficult to handle. The dispersion of oil in water is divided into free, emulsified, and dissolved states, and ceramic membranes have significant effects on the treatment of free and emulsified oily wastewater.

Mondal[7] et al. used NF270 and NF90 nanofiltration membranes to treat three types of produced water in the colorado oil field in the United States. The results showed that the NF270 nanofiltration membrane can more easily mine the produced water under high recovery (>62%). The degree dropped below 1000×10^{-6}.

Xu Xiaodong[8] et al. used 0.1μm and 0.2μm inorganic ceramic membranes to treat the water produced in Baolang Oilfield with better quality (oil content generally less than 30mg/L), and the average suspended solids content in production water was less than 0.6mg/L. The median particle size is less than 1.5μm and the oil content is below the detection limit. In addition, a large number of studies at home and abroad have also shown that the ceramic membrane technology has a better treatment effect, and it has increasingly demonstrated its strong competitiveness in the treatment of oily wastewater.

4.2 Application in textile wastewater treatment

The textile industry has a large amount of water, and the generated wastewater contains suspended substances, COD, residual bleaching agents, heavy metal substances, various types of pulp and other substances. There are many pollution components, and it is difficult to handle with conventional methods. Ceramic membrane technology Wastewater treatment is better.

Soma et al[9] used alumina microfiltration membranes to treat textile wastewater. The study found that the removal of suspended solids and organic matter was very good. The removal rate of insoluble dyes was more than 98%. At the same time, soluble dyes could be removed by adding some surfactants. The rate is greater than 97%.

NGK used Zirconia ceramic membrane to recover ZiO_2 fine particles from hydrochloric acid solution and washed it with deionized water to remove the acid radicals in the product. After treatment, the conductivity of wash water drops from 200ms/cm to 0.5ms/cm[10].

4.3 Application in printing and dyeing wastewater treatment

Printing and dyeing wastewater has the characteristics of complex composition, high content of organic matter in water, deep color, and large change in acidity and alkalinity, which is very difficult to handle. At present, the conventional treatment method is a combination of physicochemical method and biological method, but the treatment effect is not ideal. Due to the strong permeability and good mechanical properties of the inorganic ceramic membrane, it can better separate the pollutants in the filter printing and dyeing wastewater, which has drawn more and more attention.

Wu et al[11] used a ceramic membrane with membrane pore diameters of 50, 200, and 800nm to treat printing and dyeing wastewater, using a 200nm operating pressure differential of 0.2MPa, a temperature of 30°C, and a membrane surface flow rate of 4.2m/s. The ceramic membrane has the best treatment effect, with a COD removal rate of 65% and a color removal rate of 90%.

Li et al[12] used Al_2O_3 porous ceramic microfiltration membrane with a pore size of 0.2μm to treat the secondary effluent of the printing and dyeing wastewater. The results showed that COD were obtained at a transmembrane pressure difference of 0.275MPa and cross-flow velocity of 2.5m/s. The removal rate of ammonia nitrogen reached 30% and 20% respectively. Adding a certain amount of kaolin to the wastewater under the same conditions, the average removal rate of COD reached 50%.

4.4 Application in chemical wastewater treatment

The composition of chemical wastewater is complex, and the generated wastewater usually contains strong acids and alkalis. The conventional methods are difficult to handle, and the ceramic membrane technology has a better treatment effect on this kind of wastewater.

Wang Meilan et al[13] used an inorganic ceramic membrane separation device to separate sludge from water in the primary sedimentation tank in the caprolactam production wastewater treatment process. The results show that the inorganic membrane device can effectively remove SS and COD from the water, and the SS removal rate is over 90%. The effluent SS<1mg/L, the COD removal rate was 70%, the effluent COD was less than 100 mg/L, and when the inorganic film was cleaned with a mass fraction of 5% NaOH solution, the membrane flux recovery could reach 89.3%.

5 Conclusions

As a new separation technology, ceramic membrane has become a hot spot for domestic and foreign scholars to research and develop because of its obvious advantages in the field of wastewater treatment. The author believes that future research directions mainly include the following aspects:

1) Improve the manufacturing technology of membrane materials. Through scientific and technological innovation, we have improved the manufacturing technology of membrane materials, researched and manufactured high-end membrane materials, and improved the quality of membrane products.

2) Improve the performance of the membrane. Improve the adaptability of membrane products to change in operating conditions, develop low-cost, high-performance membrane materials, and reduce production costs; increase the separation efficiency and permeability of ceramic membranes, reduce operational energy consumption, and extend membrane life.

3) The application range and application depth of the extended inorganic ceramic membrane. The direction of development must be targeted and focused. It is in some areas where ceramic membranes have unique advantages, such as high-temperature water-solid separation and industrial wastewater treatment, which need to be emphasized.

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