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Study on operating flux of plate ceramic membrane treating municipal secondary effluent of WWTP

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Abstract. In recent years, plate ceramic membrane has been applied in the field of water and wastewater treatment successfully, because of its unique advantages. As an important parameter which can characterize properties of membrane, the water flux and critical flux of plate ceramic membrane treating municipal secondary effluent of Wastewater Treatment Plant(WWTP) were studied in this paper. And the flux change characteristics under different membrane pressure were obtained. The experimental results laid foundation for further exploring of mechanism of membrane fouling and related control techniques, and provided references for expanded application of plate ceramic membrane in wastewater reuse.

1 Introduction

With the rapid development of economy and the continuous increase of population, water pollution is becoming more and more serious. The shortage of water resources is becoming more and more serious. Effective treatment of wastewater and reutilization of resources is an important way to prevent and control water pollution and alleviate water shortage. China's urban municipal sewage has a large volume and has a very important potential for recovery and application. At present, the water quality of secondary effluent in most domestic wastewater treatment plants can only reach the first grade B standard. The water quality of sewage recycling is poor, it can only meet the demand of low end reuse, and the environmental risk is large, and the acceptance degree of the people is very low. At present, the upgrading and upgrading of municipal sewage plant based on the first level A standard is in full swing, but there are still many problems, such as the single technology selection, complex process, large area, and difficult process layout. Therefore, researching and development advanced treatment technology that has advanced technology, simple process and compact structure of secondary effluent of municipal sewage is imminent.

Membrane technology has been applied in wastewater treatment and reuse widely because of its advantages of high efficiency, convenient operation, compact equipment, no phase change and energy saving. At present, membrane materials used in wastewater treatment are mainly organic films[1,2]. Inorganic membrane has been paid more and more attention because of its high mechanical strength, narrow pore size distribution, high temperature resistance, corrosion resistance and so on. It has been widely used in all aspects of food engineering, environmental engineering, water treatment, medicine, and energy protection[3-5]. Membrane flux is an important parameter to characterize the performance of the membrane. The water flux and critical flux of plate ceramic membrane treating municipal secondary effluent of WWTP were studied, and the flux change characteristics under different membrane pressure were obtained. The experimental results laid foundation for further exploring of mechanism of membrane fouling and related control techniques, and also provided references for expanded application of plate ceramic membrane in wastewater reuse.

2 Materials and methods

2.1. Test raw water

The determination of pure water flux in the process of experiment is to use distilled water as raw water before membrane. The determination of critical flux is taking municipal secondary effluent from a campus as the raw water. The secondary biochemical treatment process is as follows: aeration regulation-hydrolytic acidification-anoxia-aerobic-biological contact oxidation-sedimentation-filtration-disinfection secondary effluent. Water quality indicators are shown in Table 2.1.

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Table 2.1 water quality of test water

Index	water temperature/℃	pH	turbidity /NTU	chroma	COD_{cr} /(mg/l)	ammonia nitrogen /(mg/l)	P /(mg/l)
Rang value	5~20	7.8~8.4	4~22	0.01~1	40~80	5~16	1.8~2.5

2.2 Test equipment and operation

The experimental apparatus for determining the flux of water in a plate ceramic membrane is shown in Figure 2.1. A new plate ceramic membrane was used. The pore size of the membrane was 0.1μm, the effective water area was 0.0564 ㎡, and the distilled water was the raw water before the membrane. Suction water is extracted with peristaltic pump by negative pressure suction. The peristaltic pump is BT300-2J that is adjustable speed digital peristaltic pump with a speed range of 1 to 300rpm. The vacuum pressure gauge is used to detect operating pressure on line. The volume of the filtrate is measured by a graduated cylinder.

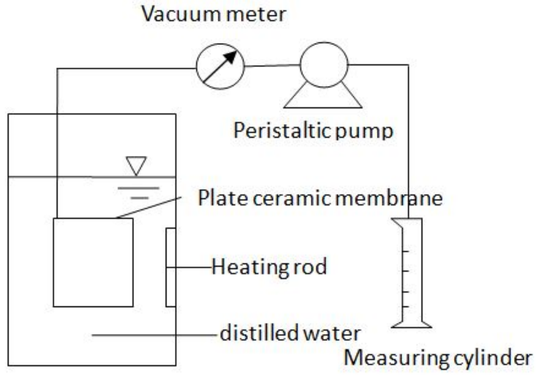

Figure 2.1 Experiment device of pure water membrane flux

The experimental device for determining critical flux of plate ceramic membrane is shown in Figure 2.2. A new plate ceramic membrane was used. The pore size of the membrane was 0.1μm, the effective water area was 0.0564 ㎡, and secondary effluent from a water station in a university was the raw water before the membrane. Suction water is extracted with peristaltic pump by negative pressure suction. The peristaltic pump is BT300-2J that is adjustable speed digital peristaltic pump with a speed range of 1 to 300rpm. The vacuum pressure gauge is used to detect operating pressure on line. The volume of the filtrate is measured by a graduated cylinder.

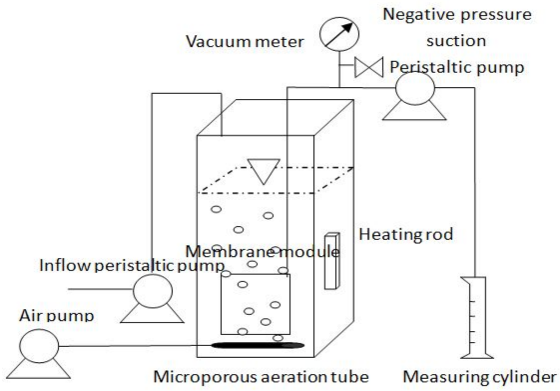

Figure 2.2 Experiment device of critical flux

2.3 Analysis method

Membrane flux was measured by volume method. In a certain time (5 minutes of this test), the volume of the filter liquid through a certain membrane area (the area of the plate ceramic membrane of this test is $0.0564m^2$) is collected by using a graduate to measure. It is calculated from (1):

$$J=V/(S\times t) \tag{1}$$

J- membrane flux ($L/ m^2\cdot h$) ;
V- volume of filtrate measured in a certain time (L) ;
S- membrane area (m^2) ;
t-the time required (h).

3 Study on flux of plate ceramic membrane

3.1. Study on pure water flux of plate ceramic membrane

The device of the test is used as shown in Figure 2-2. Using distilled water as the raw water in front of the membrane, by adjusting the rotational speed of the peristaltic pump, the operating pressure is increased gradually. The pressure gradient corresponding to each rotation speed lasts 30min, and the average flux is used as the stable flux of the plate ceramic membrane. The operating pressure is controlled at 2KPa、 5 KPa、 9 KPa 、 13 KPa and 22 Kpa, respectively. The temperature of the whole test is controlled at 25℃ by the sensor heating rod. The pure water flux of different membrane pressure is shown in Figure 3-1. As can be seen from Fig. 3.1, in a certain range, the flux of pure

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water is directly proportional to the membrane pressure. because the membrane is only affected by its own intrinsic resistance under pure water conditions. When the pressure increases to 22KPa, the average pure water flux can reach 750 L/ m^2·h.

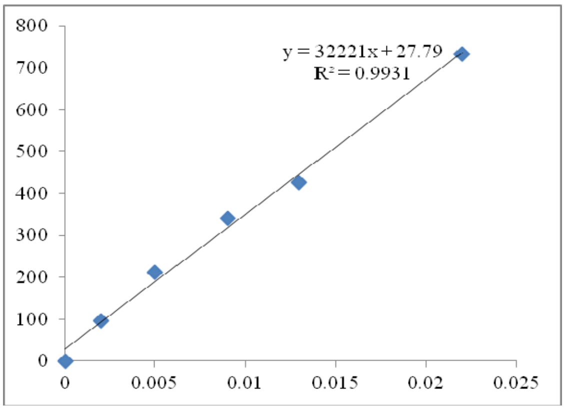

Fig. 3.1 Pure water flux of plate ceramic membrane under different membrane pressures

3.2 Study on critical flux of plate ceramic membrane

The methods of determining critical flux include flow step method, pressure step method, hysteresis effect method, working curve drawing method, direct observation method and mass conservation method. The flow step method is the most commonly used method. That is, under certain hydraulic operating conditions, the MBR is controlled continuously at a constant low flux, and the changes in the operating pressure TMP within a certain period of time are observed. If the TMP remains stable, the flux at this time is considered to be lower than the critical flux, and then the membrane flux is increased by one order, and the above experiments are repeated. By increasing the flux of membrane gradually, when MBR is just higher than a certain flux, it begins to change and can not operate stably. It is considered that the flux is higher than the critical flux at this time [6-9].

In this paper, the flux threshold method is used to determine the critical flux of secondary effluent of municipal sewage treated with plate ceramic membrane. The test device is shown in Fig. 2.2, the membrane flux is gradually increased by increasing the peristaltic pump speed, and the change of membrane pressure under different fluxes is measured.

The plate ceramic membrane is inserted into the reactor to adjust the rotational speed of the peristaltic pump, and the membrane flux is expressed by the average flux calculated by the formula (1) by the volume of the filtrate per 5min. In the first 30 minutes, membrane flux increased slowly from 0 to 4.5KPa. Increasing the speed of peristaltic pump gradually, and adjusting to 40r, 50r, 60r, 70r, 80r, 90r and 100r, respectively. The temperature of the whole experiment is controlled at 25°C by the sensor heating rod. The change of pressure and membrane flux with time is shown in Figure 3.2.

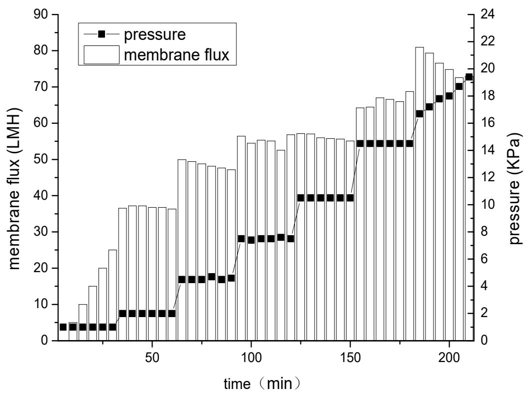

Figure 3.2 Membrane fluxes under different pressure

As can be seen from figure 3.2, under the condition of this test, when the running flux is not higher than 80L/ m^2·h, the operation pressure in the continuous suction interval of the 30min can be stable as a value. When the running flux is higher than 80 L/ m^2·h, the operation pressure increases with the change of the pumping time, and the rising rate is very fast, accompanied by the decrease of flux, which indicates that the membrane fouling is aggravated. At this time, the membrane flux decreases and the membrane pressure can not be restored to the original level. This indicates that the cake layer begins to form a cake layer and an un recoverable pollution occurs. Because of the limitation of the test conditions the increment of the flux ladder cannot be infinitely small, so an accurate critical flux can not be obtained, and only a critical flux region can be obtained. Therefore, the critical flux of plate ceramic membrane treating secondary effluent of municipal sewage by is 80 L/ m^2·h.

The above tests prove that the system can run at least 30min stably when the initial flux of plate ceramic membrane treating municipal secondary effluent is 80 L/ m^2·h.

4 Conclusions

1)Within a certain range, the flux of pure water is directly proportional to the membrane pressure, because the membrane is only affected by its intrinsic resistance under pure water. When the pressure is increased to 22KPa, the average pure water flux can reach 750 L/ m^2·h. Under the same operating pressure, the pure water flux of the plate ceramic membrane is much larger than that of the organic film and ceramic tube membrane, which is an ideal membrane material.

2)The critical flux of plate ceramic membrane treating secondary effluent of municipal sewage is 80 L/ m^2·h.

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References

1. Tian Yuelin, Liu guizhong, Yang Yongqiang, et al. Research on Inorganic Membrane Separation Technology Applicationin the Field of Water Treatment [J]. **37**（6）：16-19(2011)
2. YAO Jilun, ZHANG Xing, ZHOU Zhen, et al. Review of Ceramic Membrane in Water Treatment [J]. Journal of Chongqing University of Technology (Natural Science), **30**（12）：69-74(2016).
3. He Jun, Wang Yuechao. Development trend of inorganic membrane preparation methods and applications [J]. Jiangsu ceramics, **42**(5) : 1-3(2009)
4. Pabby A K, Ｒizvi S S H, Sastre A M． Handbook of Membrane Separations: Chemical, Pharmaceutical, Food, and Biotechnological Applications [M]. New York: CＲC Press,(2008)
5. Deng Juanli, Hu Xiaoling, Guan Ping, et al. Preparation methods and research prospects of inorganic membranes for separation [J]. Material guide, **19** (10): 40 – 43(2005)
6. DEFRANCE L, JAFFRIN M Y. Comparison between filtrations at fixedtransmembrane pressure and fixed permeate flux: application to a mem-brane bioreactor used for wastewater treatment [J]. Journal of Membrane Science , **152**:203-210(1999)
7. CLECH P L, JEFFERSON B , FELL C J D, et al.Impact of aeration,solids concentration and membrane characteristics on the hydraulic performance of a membrane bioreactor [J]. Journal of Membrane Science , **218** :117-129(2003)
8. WEI Chunhai, HUANG Xia, WEN Xianghua, et al. Operating characteristics of submerged membrane bioreactor at subcritical flux [J]. China Water &Wastewater, **20**(11):10-13(2004)
9. Yuan Dongdong, Fan Yaobo, Xu Guoliang et al. Study on critical flux theory in membrane bioreactor [J]. membrane science and technology, **30** (2): 97-103(2010)