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Research Article

Study on Integration Treatment Technology of Waste Emulsion from Machining Processing

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Abstract: The study studied the treatment technology of high concentration emulsion wastewater in metal machining plant. By analyzing the properties of emulsion wastewater, the author used the combination process of membrane technology + $Fe^{-}C$ micro-electrolysis + membrane bioreactor to treat the wastewater. Through the ceramic membrane, the removal rate of CODCr can reach 95%. $Fe^{-}C$ micro-electrolysis treatment can improve the biodegradability of wastewater, lastly through the membrane bioreactor treatment systems; CODCr of the effluent is less than 100 mg/L, which meets the requirements of The First Grade of the National Discharge Standard (GB8978-1996).

Keywords: Membrane bio-reactor, membrane separation, micro electrolysis, waste emulsion

INTRODUCTION

During mechanical processing, metal processing emulsion (mainly composed of 2-10% mineral oil, anion or non-ionic emulsifying agent and water) is required for lubrication, cooling, cleaning and anti-rust so as to reduce friction, decrease thermal effect, prolong the lifetime of the cutters and improve processing quality and production efficiency. During cycling deployment of emulsion, its salt content may increase and the stability may be decreased due to evaporation of moisture as result of being heated. The emulsion may also be transformed due to oxidation and bacteria effect. Therefore, on the one hand, some old emulsion must be continuously discharged and on the other hand the emulsion must be exchanged after being used for 2-3 months. As a result, a large amount of high-concentration waste emulsion which is difficult to be treated is produced. As oil drops in the waste emulsion are highly decentralized in the water due to effect of emulsifying agent, the particle diameter being below 1 micron, they are in the state of emulsification. Therefore, they can be treated more difficultly than the decentralized oil pollution and they are easily absorbed by plants. Most of the contained surfactant have carcinogenesis and are of great hazard (Abdullah-Al-Wadud *et al*., 2007).

As the pollution of waste emulsion from mechanical process seriously endangers the environment, environmental protectors have carried out many researches on the treatment technology during past years and have developed many treatment technologies. But for the varieties of oil pollution, miscellaneous characters of the pollution sources, largeness of discharge and high requirements for treatment, control of such wastewater is faced with huge difficulties and pressure (Bezdek *et al*., 1984). At present, treatment methods in common use can be categorized into physical method, chemical method and biological method (Gonzalez and Woods, 1992). The physical method uses physical effect to separate and reclaim suspended oil in the wastewater, such as sedimentation method, air floatation method, screen mesh filtration method, centrifugal separation method, membrane separation method and microwave-assisted treatment, etc., (Jain 1989; Ibarra-Castanedo *et al*., 2004). Chemical method uses demulsification effect to treat emulsifying oil in the water such as coagulation sedimentation method, absorption method, salting-out method, acidification method, electrochemical method, etc., (Antoni ROgslski, 2002). Biological method uses microorganism effect to remove colloidal particle oil drops and dissolved oil such as bio-membrane method, activated sludge method and bio-oxidation pond method (Berthel *et al*., 2008). Each treatment method has its own characteristics and application conditions. In practice, as different emulsion has different characters, single method can hardly achieve ideal effects. As a result, only few treatment technologies have been put into actual industrial application.

On the basis of sufficient investigations and researches on the characteristics of waste emulsion produced from aluminum processing enterprises, this

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Table 1: Physical-chemical properties of waste emulsion

pH	CODCr/ (mg/L)	Petroleum/ (mg/L)	Conductivity/ (μs/cm)
7-8	(1.6-2.4) ×104	31.3×103	432

essay develops new waste emulsion treatment technology, i.e., adopts combined treatment technology of ceramic membrane-iron-carbon micro electrolysis-Membrane Bio-Reactor (MBR) to treat waste emulsion. And industrial tests have been carried out. The test results show the wastewater treated by the combined technology can reach the national first-grade wastewater discharge standard. They can be reclaimed and reused in the production area for the purpose of energy-saving and emission reduction as well as environmental protection. Besides that, this treatment technology provides a new and highly-effective treatment method for the treatment of the same kind of wastewater and therefore has a very important environmental benefit and social benefit.

EXPERIMENTAL RESEARCHES

Experimental equipments and materials:

- **Ceramic membrane:** Ninteen-channel tubular membrane provided by one company in Shanghai. The membrane supports and materials are both α-Al_2O_3. The membrane pore size is 0.1 μm and the effective area is 0.1 m^2.
- **Iron-carbon micro electrolysis system:** Composed of ironic scraps, carbon particles and new imported filling materials. The main function of the system is to improve the biodegradability of the ceramic membrane produced water. It is generally recognized that when BOD_5/COD (B/C) is less than 0.2, the wastewater can hardly be biodegraded. As for the wastewater concerned in this essay, B/C is less than 0.10; therefore, biodegrading treatment can hardly be carried out without special pre-treatment.
- **MBR system:** Outside membrane bio-reactor which is composed of biochemical pond, booster pump and hollow fiber ultra-filtration membrane is used.
- **Waste emulsion:** The waste emulsion used for the test comes from one aluminum rolling factory which is equipped with thermal rolling and plain rolling equipments. The waste emulsion produced from different technologies has different characteristics. Besides, the fact that the emulsion used by the company is imported from different sources also makes the characteristics of waste emulsion different from each other. This test adopts the waste emulsion whose emulsification properties are stable and which can hardly be treated. The water quality analysis of the emulsion is showed in Table 1.

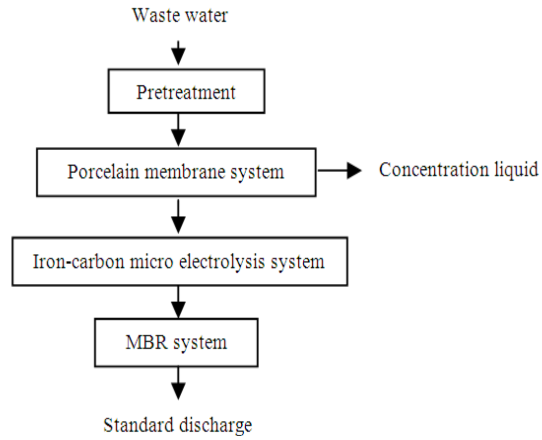

Fig. 1: The process flow of the test

Experimental methods:

- **Pre-treatment:** Filtrate the waste emulsion with nonwoven fabric filter cloth to remove big-granule suspended substance.
- **Ceramic membrane treatment:** Exert a certain pressure to make waste emulsion penetrate the ceramic membrane and analyze the water quality of the outlet water after being filtrated by the membrane and change of the membrane permeate flux.
- **Iron-carbon micro electrolysis treatment:** Acting as the pretreatment of inlet water of MBR system, it can improve the biodegradability.
- **MBR treatment:** Through cultivating acclimated and activated sludge, it can degrade the organism in the wastewater and analyze the outlet water quality.
- The test takes the CODCr removal rate as the main analysis index. Among them, CODCr adopts potassium dichromate method for analysis while BOD_5 adopts dilution inoculation method for analysis.

Process flow of the test: The Technological flow of the test is as shown in Fig. 1.

RESULTS AND DISCUSSION

Ceramic membrane treatment test: Ceramic membrane treatment system is the key unit of the test. The ceramic membrane is the asymmetrical separation membrane made of α-Al_2O_3. It appears multi-center tubular structure and the tubular wall is densely covered with micro pores. Its working principle is as below: under outside pressure, emulsion is cross-flowed in the membrane tube. The part smaller than the pore size enters into the penetration side through the membrane

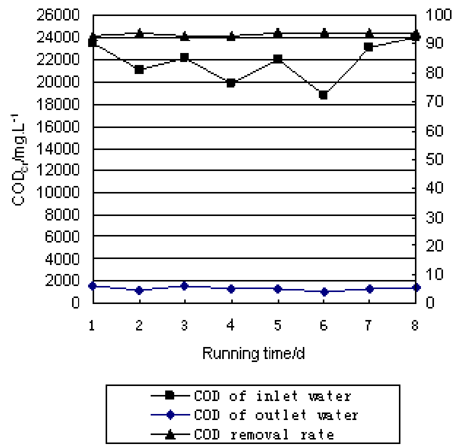

Fig. 2: Inlet and outlet water CODCr change for porcelain system

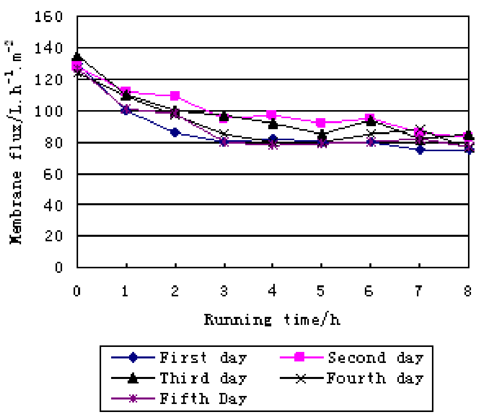

Fig. 3: Change curve for ceramic membrane flux

pore and becomes filtration liquid while the substance bigger than the membrane pore is withheld by the membrane and become concentration liquid. As a result, separation of water and oil is realized.

The results of ceramic membrane treatment test show that under the flow rate of membrane surface of 5.8 L/s and the operational pressure of 0.15 Mpa and under the condition of room temperature, if suitable membrane cleaning mode is adopted, the treatment effect is stable. The test result is as shown in Fig. 2. From Fig. 2, we can see that when the inlet water quality is fluctuating, the CODCr removal rate of the filtered water through ceramic membrane may retain above 90% and the filtered water CODCr is in average above 2,000 mg/L.

The ceramic membrane should be cleaned on daily basis after being operated so as to basically resume its flux. After the ceramic membrane system operates stably, it shall operate for 5 continuous days for 8 h each day. The change of the membrane flux is checked and the result is as shown in Fig. 3. From Fig. 3, we can see that in the first 1-2 h of operation, the membrane flux is quickly reduced. Two hours later, the flux

Table 2: CODCr removal rate of iron-carbon micro electrolysis treatment system

Inlet water CODCr/mg/L	Outlet water CODCr/mg/L	Inlet water B/C	Outlet water B/C	CODCr removal rate
1250	953	0.08	0.23	23.8%
1652	1224	0.10	0.26	25.9%
1547	1196	0.08	0.35	22.7%
1384	977	0.07	0.28	29.4%
1319	976	0.11	0.31	26.7%
1126	846	0.07	0.32	24.9%
1386	998	0.09	0.27	28.0%
1439	1059	0.10	0.25	26.4%

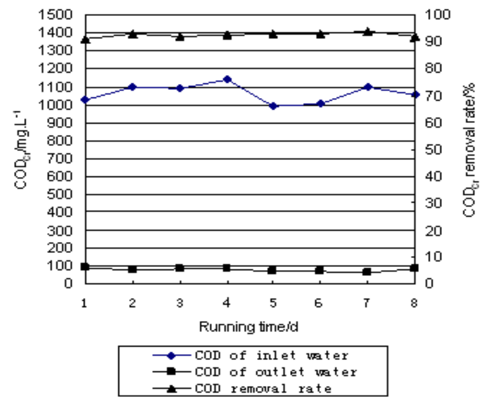

Fig. 4: CODCr change curve of MBR treatment system

remains stable. After 8 continuous h, the flux basically remains at 90 L/(h/m^2). It shows that under fitting conditions, the flux may maintain in stable scope which facilitates industrialized applications.

Iron-carbon micro electrolysis treatment: The iron-carbon micro electrolysis in the test uses the micro primary cell reaction formed by electrode and potential difference among iron scraps and carbon particles to generate Fe^{2+} and atom H with high chemical activity so as to change the structure and properties of many organic materials in the wastewater and further to promote occurrence of chain scission and open-loop and finally to improve the biodegradability of the wastewater. The added new imported filling materials simultaneously may settle the problem that the traditional iron-carbon micro pond is easily hardened and consequently cause unstable operation of the treatment equipments.

The test result of iron-carbon micro electrolysis treatment is shown as in Table 2. The test shows that the B/C value (BOD_5/CODCr) of the wastewater through iron-carbon micro electrolysis may reach 0.3. The biodegradability is largely enhanced. Besides, this process may reduce 20-30% of CODCr so as to relieve the burden caused by the following treatment.

Membrane bio-reactor treatment: The biodegradability of the wastewater after iron-carbon micro treatment is enhanced but the value is still not high enough. Besides, the dissolving oil and other contents which may inhibits growth of organic materials contained in wastewater make the acclimation process comparatively difficult. It lasts for almost 1 month from the inoculated sludge entering into the aeration tank to basically stabilize operation of the bio-chemical system. After the sludge is successfully acclimated, the organic substance in the system has basically been adapted to the water quality properties of the wastewater and a certain anti-impact ability against the inlet water quality fluctuation is also formed. The test result is shown as in Fig. 4. From Fig. 4, it shows that the CODCr removal rate after MBR system treatment averagely reaches above 90%. And the outlet water CODCr is between 70-90 mg/L, lower than the national first-grade discharge standard.

CONCLUSION

This test adopts the technology combining ceramic membrane-iron-carbon micro electrolysis-membrane bio-reactor to treat waste emulsion from mechanical processing and the result is cheerful. The conclusions are summed up as below:

- Ceramic membrane can remove 93-94% CODCr so as to make CODCr reduce from tens of thousands mg/L to below 2,000 mg/L while keeping the ceramic membrane flux stable.
- After the outlet water from ceramic membrane is treated by iron-carbon micro electrolysis method, the biodegradability of the wastewater can be effectively enhanced. After entering into the MBR treatment system, the CODCr removal rate may reach above 90% while keeping the system stably operated.
- Ceramic membrane+iron-carbon micro electrolysis +MBR technology may make the outlet water CODCr of waste emulsion decrease to 70-90 mg/L, lower than the national first-grade wastewater discharge standard, which creates favorable conditions for further reclamation of wastewater.

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