

环境科学

超重力技术在工业废水处理中的应用研究

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摘 要 介绍了新型应用超重力技术处理废水的旋转填料床工作原理,列举了旋转填料床在诸多工业废水中的应用研究。并对超重力技术在工业废水处理进行了展望。

关键词 超重力技术 废水 旋转填料床 撞击流-旋转填料床

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Water is the most essential material for all lives on the earth and a kind of precious natural resource on which human beings rely and develop. As the industry and agriculture develop rapidly and the number of urban population enlarges drastically in the world, the water need in productivity and life also increases fast. Meanwhile, many water sources are seriously polluted by the under - standard release of large amount of wastewater, which results in the severe water shortage both at home and abroad. So stopping water pollution and protecting water environment has become a global issue, and also the most urgent one in China's environment protection. As a result, it is of great necessity to research the new technology, means, and equipment to dispose of wastewater. The high gravity technology, since its birth, has shown its advantages in the disposal of wastewater^[1,2]

1 High gravity technology

High gravity technology, as an effective means for intensifying transfer process, has wide and strong com-

mercial potential in chemical engineering, energy industry, environment protection, materials, bio-chemicals, etc. The high gravity equipment, rotating packed bed (RPB), has some characteristics, such as smaller volume and lighter weight, larger transfer efficiency, lower gas pressure drop, easy operation, easy maintenance, etc.^[3,4]. So it has "the transistors of chemical industry" title. Theoretically, high gravity technology can be applied to all chemical units.

1.1 Basic structure of RPB

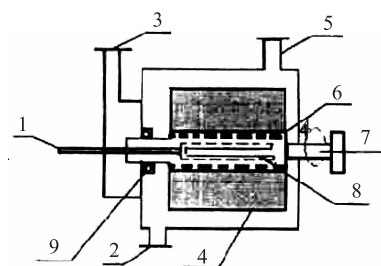


Figure 1 Structure of RPB

1—entrance of liquid, 2—exit of liquid, 3—exit of gas, 4—packing, 5—entrance of gas, 6—inner support of packing, 7—rotating axis, 8—distribution tool of liquid, 9—airproof equipment

1.2 The principle of RPB

The gas gets into the external cavity of the axis tangentially through the gas entrance pipe, and then

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comes into the packing from the outside of the rotating axis under air pressure. While the liquid goes into the internal cavity through the liquid entrance pipe, then is sprayed on the inside edge of axis. When the liquid in the rotating axis is pressed by the packing, its encircling speed increases and the centrifugal force the speed causes pushes the liquid to the outside of axis. In this process, the liquid is separated and crashed by the packing, which makes enormous and consistently renewed surface area, and the curve flowing lane enhanced the renewal of the liquid surface, which, therefore, results in excellent transfer and reaction condition inside the rotating axis. When the liquid is cast out of the axis, it flows off the RPB from the liquid exit pipe. The gas moves away from the axis through the rotating center and gets out of the gas exit pipe. Then the transfer and reaction procedure is accomplished.

1.3 The characteristics of RPB

- 1) Greatly strengthen the transfer process, mass transfer unit height of only (1 ~ 3) cm.
- 2) Greatly reduce the equipment size and weight (not only reduces investment, but also increased the improvement in the environment).
- 3) Material in the device within a very short residence time (10 ~ 100) ms.
- 4) Gas pressure drop through the device similar to the traditional equipment.
- 5) Easy to operate, easy-to-open parking, from start to enter the steady-state operation is very short (in 1 min).
- 6) Operation maintenance and check the degree of convenience in comparison with centrifuge.
- 7) Can be vertical, horizontal, or any direction to install, are not afraid of vibration and bumps, can be installed on the moving object.
- 8) Rapid and uniform micro-mixing.
- 9) Packing layer has self-cleaning effect is not easy plugging.

10) It is easy to miniaturization for special occasions, but also easy to industrialization to enlarge.

2 The Applications in Treatment of Industrial Wastewater

By using the above-mentioned advantages of RPB, many of the world largest chemical companies and research institutions are competing for high-gravity technology research and development, now RPB have been applied to desorption, absorption, distillation, polymer devolatilization, bio-oxidation, and reactive crystallization, *etc.*

High gravity technology can greatly improve transfer efficiency, and shrink the dimension of the equipment, so it will have better effect on wastewater disposal which is controlled by transfer. This paper is mainly about the researches into wastewater disposal by applying high gravity technology.

2.1 The treatment of ammoniac nitrogen wastewater^[5-8]

This research project has been carried out in the Research Center of Shanxi Province for High Gravity Chemical Engineering and Technology since 1999. After years of effort, the high gravity net packing is applied to deal with the ammonia & nitrogen wastewater in the methanol equipment in Taiyuan Fertilizer Factory. The experimental conditions and results are as follows: using air as stripping, temperature, 40°C; rotating speed of the rotating factor, 1 200 r/min; the quantity of ammonia & nitrogen in wastewater, (1 500 ~ 2 000) mg/L; pH value, 10 ~ 11; the gas to liquid ratio, 1 200. Under the above conditions, the lowest height of transfer unit is 20 mm, the single elimination rate can be 85% and the double reverse elimination rate can reach 98%. The ammonia density in the exit is lower than that of the national wastewater releasing standard, which enables the factory to realize the clean producing. The re-

sult shows that by using the method, we can make the equipment much smaller, lower the energy exhaustion, and make it easier to regain ammonia, which could not only greatly reduce the environmental pollution, but also make the wasted useful, and decrease the waste of source materials. The technology passed the authentication of the technological achievement in Shanxi province in 2000 and came to the top level in the world. In 2002, it was authorized the national key promoting project of the technology achievement.

2.2 The treatment of phenolic wastewater^[9,10]

The optimum condition was determined about making emulsion liquid membrane by impinging stream & rotating packed bed (IS-RPB) and treating phenolic effluent by RPB proposes by Yang Lirui and others. The influence on extraction rate of the rotating speed of making emulsion, the ratios of water to emulsion, the dosage of Span 80, the content ration of NaOH, the flux of extraction were discussed. The best rate of extraction may reach 99 % and the operation is fast and simple. This study supplied a new way to treat phenolic effluent by the way of emulsion liquid member.

2.3 The treatment of dye wastewater^[11]

Diao Jinxiang and others studied a novel rotating packed bed used in the ozone oxidative treatment of dye wastewater. And ozone oxidation experiments were conducted to examine the effects of various operation variables, including high gravity factors β , initial pH of dye wastewater and gas to liquid ratio on the decolorization efficiency. Experimental results indicated that the decolorization efficiency increased with increasing high gravity factors and ratio of gas to liquid ratio. However, the effect was not obvious at a high gravity factor higher than 100. The decolorization efficiency increased with increasing pH value initially, and then gently decreased. The optimal initial pH value was 10 ~ 11. Compared with conventional O_3 contactors, a rotating packed bed could be used to increase the efficiency of the ozone oxidative treatment of dye

wastewater, due to its high mass transfer characteristics.

2.4 The treatment of TNT Red-Water^[12]

The specific property of the O_3/H_2O oxidative treatment of TNT red water in a rotating packed bed was further studied by Diao Jinxiang and others. The experiments were carried out to examine the effect of various operating variables, such as high gravity factors β , the molar ratios of H_2O_2 to O_3 , initial pH value of red-water and ratio of liquid to gas on the removal efficiency of COD in red-water. The results show that the effect of high gravity factors on the removal efficiency of COD in red-water increases with increasing of initial pH value of red-water. However, the effect is not obvious as high gravity factors are higher than 100. And the removal efficiency of COD increases with increasing of ratio of liquid to gas, then decreases with increasing of ratio of liquid to gas. The optimum process conditions are found when the initial pH value is about 11, themolar ratio of H_2O_2 to O_3 is about 1, and the ratio of liquid to gas is about 0.25.

2.5 Application of urea hydrolysis process^[13]

High Gravity Engineering and Technology Research Center Attached to Beijing University of Chemical Technology cooperated with a big enterprise of China Petroleum Corporation with synthetic ammonia as its product. They developed a high gravity urea hydrolysis industry siding, which can dispose of water with the amount of 5 t/h. The experiment showed that high gravity urea hydrolysis equipment can reduce the urea content in wastewater from 100 mg/L to below 5 mg/L when the equipment worked under the condition of 220℃ ~ 230℃, (214 ~ 216) MPa, which can meet the water demand of medium pressure boiler. It is not only good to environment, but also benefit the society and economy.

3 Conclusion

Better living environment and higher quality of life is expected, so the waste water and gas, which is given off in the process of industrial production must be disposed. High gravity RPB technology has the advantage of high efficiency in transfer and low energy consumption, therefore, its application in environmental industry is of great concern. With the further development of high gravity technology, it is certain that its application research on the industrial sewage and sanitary waste can be greatly widen to make a contribution to sustainable development of human being.

References

- 1 Guo Kai, Liu Songnian, Chen Jianfeng, *et al.* Recent progress of high gravity technology. Chemical Industry and Engineering Progress, 1997; (1): 1—4
- 2 Wang Yuhong, Guo Kai, Chen Jianfeng, *et al.* Higee technology and its application. Metal Mine, 1999; 274(4): 25—29
- 3 Ouyang zhaobin, Liu youzhi, Qi guishen. A new type reaction facility-rotating packed bed technology and its application. Science & Technology in Chemical Industry, 2002; 10(4): 50—53
- 4 Zhao Xiaoxi, Deng Xianhe. High gravity technology and its application in environmental protection. Environmental Protection of Chemical Industry, 2002; 22(3): 142—146
- 5 Liu Laishuan, Xie Guoyong, LIU Youzhi. Experimental study on treatment of ammoniac nitrogen wastewater with rotating packed bed. Journal of North China Institute of Technology, 2002; 23(3): 222—225
- 6 Jiao Weizhou, Liu Youzhi, Liu Jianwei, *et al.* Pilot study on coking ammonia-nitrogen wastewater by high-gravity rotary bed. Modern Chemical Industry, 2005; 25: 257—259
- 7 Jiao Weizhou, Liu Youzhi, Zhang Deyu. The application of high gravity rotating packed bed in environmental industry. Sichuan Environment, 2005; 24(1): 78—82
- 8 Qi Guisheng, Liu Youzhi, Wang Jianwei. Stripping ammonia-nitrogen wastewater by high gravity method. Coal Chemical Industry, 2007; 1: 61—63
- 9 Yang Lirui, Liu Youzhi, Qi Guisheng, *et al.* Study about treating phenolic effluent through emulsion liquid membrane by impinging stream-rotating packed bed. Shaanxi Chemical Industry, 2004; 33(3): 31—33
- 10 Yang Lirui, Liu Youzhi, JIAO Weizhou, *et al.* A study on treating waste water of phenol through impinging stream - rotating packed bed by the way of emulsion liquid membrane(II). Science & Technology In Chemical Industry, 2004; 12(1): 40—43
- 11 Diao Jinxiang, Liu Youzhi, LI Peng, *et al.* Experimental studies on ozone oxidative treatment of dye wastewater in a rotating packed bed. Chemical Industry and Engineering Progress, 2007; 26(4): 542—544
- 12 Diao Jinxiang, Liu Youzhi, Wang He, *et al.* O₃/H₂O₂ oxidative treatment of TNT red-water in a rotating packed bed. Chinese Journal of Energetic Materials, 2007; 15(3): 281—284
- 13 Chen Jianfeng. Higee technology and its application. Beijing: Chemical industry press, 2002

High Gravity Technology in the Application of Industrial Wastewater

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[Abstract] To begin with the principle of RPB is used in the wastewater disposal by applying the new high gravity technology, and studied the applications of RPB in disposing of wastewater. Besides, the further study of high gravity technology in wastewater disposal is put forward.

[Key words] high gravity technology wastewater RPB IS-RPB