Experimental Research on Advanced Treatment of Secondary Wastewater Treatment in Dairy Processing Industry by Reverse Osmosis

Jiang Tao, Wang Shuai, Wei Lina, Shan Dechen, Zhang Yun
East University of Heilongjiang, Harbin City, Heilongjiang Province, 150080

Abstract: This article will study the application of reverse osmosis advanced treatment technology in the secondary processing of wastewater in the dairy processing industry from the perspective of wastewater quality characteristics, and discuss the characteristics, application principles, and experimental design of the technology. This article will further analyze the effects and existing problems of deep treatment of reverse osmosis through experiments. Through a series of tests, we found that the temperature of the inlet water, the pressure of the system operation, the quality of the inlet water, etc., will all have a certain effect on the efficiency of the deep treatment of reverse osmosis and the long-term stable operation of the device. Then, this paper proposes some improvement and optimization measures for these problems. Through the long-term operation test, it is found that the most prone problem in the operation of the reverse osmosis device is the problem of membrane fouling. Based on this, an optimized treatment process based on the dairy processing industry secondary treatment wastewater treatment project is proposed. For one thing, this process can improve the water production rate and the recovery utilization rate of the secondary treatment wastewater. For another, it can reduce membrane pollution, reduce the cost of system operation and maintenance, and increase the service life of the device.

1. Reverse Osmosis Membrane Materials and Principles of Advanced Treatment

1.1. Reverse Osmosis Membrane Materials
The reverse osmosis membrane has the characteristics of convenient operation, high desalination rate, good selectivity and compatibility, and low energy consumption. At the same time, the reverse osmosis membrane has been modularized, the treatment is relatively stable and reliable, and it is easy to realize automatic control. Membrane materials mainly include acetate fiber bundles, aromatic polyamide materials and polysulfone materials, polybenzimidazole materials, polyphenylene ether, polyvinyl butyral, etc.

1.2. Reverse Osmosis Pretreatment Technology
Reverse osmosis pretreatment technology has been widely used in the reuse of highly polluted wastewater, including conventional capillary filtration technology and ultrafiltration technology. According to the filtration principle, when the particle size is larger than the pore size of the membrane, the membrane will prevent the particles from passing through and stay on the surface of the membrane, making it difficult to aggregate or stay on the surface of the membrane. After pretreatment, the harmful substances in the wastewater can be excluded, and the water quality entering the reverse osmosis advanced treatment device can be ensured to minimize the pollution of the...
membrane. Among them, the ultrafiltration technology makes the effluent water quality more stable, greatly reducing the impact on the raw water quality, and the system has a high degree of automation, easy operation and stable operation. After ultrafiltration pretreatment, it can effectively retain organic matter and reduce organic matter pollution to the reverse osmosis membrane, and can also effectively retain colloidal pollution, thereby reducing the degree of water pollution.

1.3. Principle of Reverse Osmosis Membrane Materials
First, the working principle of the pretreatment technology is to screen the feed liquid to prevent the passage of macromolecular substances, and to achieve basic purification, separation and concentration of the feed liquid. The principle of reverse osmosis technology is to use reverse osmosis membrane to remove various ions, molecules, organic matter, colloidal pollutants, bacteria and viruses in water. The reverse osmosis membrane can only let water pass. As the penetration continues, the concentrated solution will be diluted due to the entry of fresh water, and the resistance caused by the flow of fresh water to the concentrated solution can prevent the fresh water from continuing to enter the solution to balance the penetration process. The technology has the advantages of high efficiency, low energy consumption, no pollution, etc. In addition, because of the simple process, small footprint, high degree of automation, and continuous treatment of water, reverse osmosis treatment technology has been widely used.

2. Determine the Test Plan

2.1. Experimental Design
(1) Test Procedure
According to the analysis of the water quality of the test influent, ion exchange and electrodialysis can be used to remove anions and cations in the water. However, the treatment efficiency of these measures is low, and new technologies and equipment are needed to remove organic matter and suspended matter that are difficult to be degraded in water, and the problems of water saving and high water recovery rate must also be considered. The specific experimental process is designed as follows: First, analyze the source of raw water, analyze the COD, residual chlorine and salt content in the raw water before entering the system, and analyze the raw water quality to facilitate the comparative analysis of post-treatment effects. Second, ultrafiltration pretreatment of the raw water is used to remove bacterial residues and colloidal particles in the water, so that the effluent meets the requirements of the reverse osmosis device. This is also to protect the reverse osmosis membrane by adding scale inhibitors to avoid the occurrence of precipitation of slightly soluble salts. The reverse osmosis effluent enters into the original water tank of the ion exchange unit and the pretreatment is
completed, and then enters the reverse osmosis advanced treatment process.

(2) Test Device Design
The core part of the test device is a semi-permeable membrane. The semi-permeable membrane has poor dirt resistance, and can react with particulate matter, colloidal particles, solute macromolecules, etc. in sewage, so that certain solutes can be adsorbed and deposited in the membrane pores. However, it is easy to cause the membrane pore size to become smaller or even congestion, which changes the membrane flow rate and separation characteristics, and directly irreversibly damages the membrane effect. Therefore, the design of the reverse osmosis device has high requirements for the reverse osmosis membrane. The reverse osmosis membrane also requires high water hardness, turbidity, and pollution index. Therefore, we should add quartz sand filtration and activated carbon adsorption for pretreatment.

2.2. Experimental Materials and Instruments
(1) Reasonable Choice of Experimental Membrane Materials
At present, common reverse osmosis membranes are all composite membranes, and the separation layer will have the following effects on the performance of the membrane: First, the permeation flux of the membrane is inversely proportional to the thickness of the separation layer. Second, the thinner the separation layer, the membrane flux will get much more great. Third, if the separation layer is porous, the greater the porosity, the greater the permeation flux of the membrane. Fourth, as the upper pore distribution of the separation layer is getting smaller, we will achieve the higher the purity of the separated product. Common composite membrane modules are hollow fiber type, spiral wound type, capillary type and plate and frame type.

(2) Laboratory Apparatus
Experimental instruments include turbidity meter, electromagnetic flowmeter, conductivity meter, pressure gauge, sodium ion concentration meter, heating equipment, chronograph stopwatch, inlet flow meter and outlet flow meter, etc.

2.3. Experimental Method
Take the raw water sample of the production enterprise into the inlet tank, start the lift pump, and then adjust the flow control of the ball valve to make the pretreatment effluent enter the intermediate tank, keep the equipment running stably for 5 minutes, and then start the high pressure pump and reverse osmosis device to control the water inlet pressure of reverse osmosis. After keeping the test device running stably for half an hour, the raw water, quartz sand filter tank and activated carbon adsorption tank effluent, reverse osmosis effluent and reverse osmosis concentrated water were used for the analysis of test results. After half an hour, add the raw water to the raw water tank, and after stabilizing for half an hour, repeat the above operation. The whole experiment process should last at least about two months, and the experimental result data should be taken every few days for analysis, and finally the average value of several groups of data should be analyzed and processed.

2.4. Analysis of Experimental Results and Analysis of Water Quality Indicators
After the pretreatment, the water turbidity and pollution index meet the reverse osmosis influent requirements, which means that the pretreatment effect is better, without adverse effects on the reverse osmosis membrane, the reverse osmosis system is safe and stable, otherwise we need to optimize and adjust the pretreatment device and the treatment method. Specific treatment effects include the following. First, the removal effect of reverse osmosis on CODcr, measurement and analysis of the treated water quality, sand rate and activated carbon can remove a certain amount of CODcr, after the deep treatment of reverse osmosis, the entire reverse osmosis operating system. The removal rate of CODcr reached more than 85%, indicating that the device has a certain anti-load capacity for the removal of CODcr, and meets the requirements of recycled water quality. Second, the effect of reverse osmosis advanced treatment on TP removal. After the device is stabilized, the phosphorus content in the water sample is detected. The measurement results are as follows: the TP concentration in the
water sample is high, and the biological phosphorus release cannot be performed. The filtration is basic. It does not play the role of phosphorus removal, the effect of reverse osmosis on phosphorus retention is more obvious, and the total removal rate of TP by the system reaches about 90%. Third, the removal effect of reverse osmosis on hardness is not obvious after the pretreatment of sand rate and activated carbon, but after deep treatment with reverse osmosis membrane, the removal rate can be as high as 99%, so that each reused water meets the standard Recycling requirements and keep the hardness of the water stable. Fourth, the water production rate of reverse osmosis is used to collect the production water and concentrate water of the test device, and conducting a ratio analysis of the production water and concentrated water, it was found that the water production rate of reverse osmosis was stable. In addition, because the configuration of the membrane is two parallel, according to the single membrane recovery rate of 15% is required, and the water production rate within a reasonable range can indicate that the reverse osmosis operation device is operating well.

3. Influencing Factors of Reverse Osmosis System Operation and Optimization Improvement Measures for Reverse Osmosis Operation System

3.1. Factors Affecting the Operation of Reverse Osmosis System

(1) Concentrated Water Discharge
If the value of concentrated water discharge exceeds the standard value, this extra concentrated water cannot be directly discharged into natural water bodies. If it is directly discharged into the sewage plant, the high salt content will directly cause the concentrated water to not be recycled. Although there are already some advanced concentrated water treatment facilities for deep oxidation to reduce organic matter, the overall reduction effect is not obvious.

(2) Water Quality
In order to prevent the reverse osmosis membrane from being polluted or damaged and affecting the stable operation of the overall reverse osmosis device system, it is necessary to control the quality index of the waste water. For wastewater that has undergone secondary sewage treatment, if the chemical device of the original water source fails, it will affect the quality of the discharged wastewater and cause large fluctuations in the quality of the wastewater. In the actual operation of the device, it can be treated by reducing the amount of waste water and increasing the amount of fresh water supplement. Although these methods can achieve good results, in the long run, with the accumulation of pollutants, there will still be irreversible pollution problems, which will eventually lead to increased costs. It will also affect the water production rate, shorten the operating life of the system, and cannot achieve the ideal reverse osmosis treatment effect.

(3) Membrane Fouling
Common membrane pollution includes colloidal pollution, structural pollution, metal oxide pollution and microbial pollution. In addition, after the formation of organic scales and inorganic silicate scales on the surface of the membrane, membrane pollution will reduce the water permeability, increase the pressure drop and the salt permeability. In order to completely remove the contaminants on the surface of the membrane, it can be solved by cleaning the membrane to restore the membrane to its original state as soon as possible. Colloidal contamination can cause clogging of the membrane surface, reducing water permeability and increasing system pressure. Carbonate scale is mainly generated on the reverse osmosis membrane, which leads to a decrease in the desalination rate of the reverse osmosis membrane and increases the concentration polarization on the membrane surface. Metal oxide contaminants deposit on the surface of the membrane and cause the metal concentration to decrease. After oxidation, the amount of infiltrated water will decrease. Microbial pollution generally occurs in the reverse osmosis system, which will cause problems such as an increase in the operating pressure difference of the reverse osmosis system, a decrease in the amount of permeated water, and an irreversible microbial pollution.

(4) Other Influencing Factors
Other influencing factors such as device operating temperature, operating pressure, flowing water...
flow rate, membrane aging, salt content and insoluble substances will also have a certain impact on the operation of reverse osmosis system. Especially in the case of seasonal changes, or the failure of pumps, valves and other equipment, it will cause certain changes in temperature, pressure, water flow rate and reverse osmosis membrane, which will cause system quality problems.

3.2. Reverse Osmosis System Operation Optimization Measures

(1) Adjust the Temperature

The inlet water temperature of the reverse osmosis membrane should be controlled between 5 and 40 °C. At the same time, the inlet water temperature will also have a great influence on the reverse osmosis water production. As the operating temperature decreases, the viscosity of the water will increase, thereby reducing the speed of water passing through the reverse osmosis membrane. The membrane water production will decrease by 3% for every 1 °C temperature drop. Generally, the temperature in summer can meet the production requirements, but after the water temperature drops to below 20 ℃ in winter, the pressure difference of the produced water will increase rapidly, so that the water production cycle will be reduced. A pipeline heater can be added to the device, and the steam line is directly connected to the waste water line through the static mixed gas, and then enter the raw water tank and mixed with fresh water, so that the water temperature can be controlled at about 25 ℃ during normal operation, because the water temperature is 25 At around ℃, the water production increased significantly.

(2) Determine the Recovery Rate of Concentrated Water

A set of concentrated water recovery system was added to the original test device, so that a part of the extra concentrated water was recovered into the original water tank, and then mixed with the wastewater after the secondary pollution treatment as raw water to the reverse osmosis device for effective treatment. In general, the amount of concentrated water recovered accounts for 1/3 of the total concentrated water. Since the proportion of recovered concentrated water in the raw water is small, it does not affect the mixing of wastewater and fresh water. After part of the concentrated water is recovered, the reverse osmosis recovery rate is significantly improved. After the operation of concentrated water recovery, it was found that after the reuse of concentrated water, the flow rate of reverse osmosis concentrated water increased, and the flow rate of concentrated water in the membrane increased, thereby effectively controlling the clogging or fouling of membrane microorganisms, which has a good effect on the operation of reverse osmosis.

(3) Determine the Reverse Osmosis Feed Water and Add Acid

In the reverse osmosis desalination process, CO2 can fully penetrate the reverse osmosis membrane, but calcium ions are basically impermeable to the reverse osmosis membrane, so that the water is further concentrated. At a recovery rate of 75%, the concentration of concentrated water is concentrated four times, resulting in the pH of the concentrated water being alkaline and increasing the concentration of calcium ions. It reacts with the bicarbonate in the water to generate carbonate ions, carbonate ions. It will also react with calcium ions to produce calcium carbonate precipitation, which will block the membrane surface, resulting in a decrease in the water permeability and desalination rate of the reverse osmosis membrane. Therefore, in order to increase the service life of the membrane on the basis of ensuring the optimal pH value of the membrane element, we must reasonably determine the addition of acid to the reverse osmosis inlet water, which not only reduces the pH of the water and thus inhibits the formation of carbonate ions, reduce the occurrence of calcium carbonate precipitation, but also improves the application quality of the membrane.

3.3. Effectiveness Analysis

Through the optimization of temperature adjustment, determination of concentrated water recovery rate, addition of reverse osmosis feed water and acid, it can reduce the discharge of concentrated water, increase water production, and reduce the problem of reverse osmosis membrane being blocked by calcium carbonate precipitation. From a technical point of view, with the continuous progress of reverse osmosis technology, this technology can be widely used in industrial production. Economically,
the use of advanced reverse osmosis treatment process, using wastewater as a source of water can reduce the use of fresh water, and also reduces the amount of acid and alkali, reduces wastewater discharge, optimizes the environment, and lowers the overall cost of water production.

4. Conclusion
In summary, using pretreatment measures such as sand rate and activated carbon, combined with deep reverse osmosis treatment, this process is applied to the recycling of processing wastewater in the dairy processing industry. The effluent indicators for CODcr, TP and hardness can meet all the reuse water index. Therefore, the removal effect of hardness is good, the water production rate is stable, and the entire reverse osmosis device has not been polluted after several months of operation. In addition, if the upgrade and optimization of membrane modules and other device improvements can be achieved in actual projects, the effect and efficiency of the reuse water treatment can be further improved, and the water production rate can be greatly improved.

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