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Application Research of Internal Circulation Coarse-Grained Reactor Based on Feedforward Compensation Control

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ABSTRACT. *This article uses a new type of internal circulation coarse graining reactor based on feedforward compensation control to treat oily wastewater from oil fields, which can effectively reduce the oil and suspended solids, thereby reducing the processing load of subsequent processes and improving the quality of the final effluent. Through the pilot test, it is determined that the oil removal period is about 22h, and the turbidity removal period is longer than 53h. In the effective oil removal period, the average oil removal rate is about 50%. During the operation time of the device, the average turbidity The removal rate is about 95%.*

KEYWORDS: *Oilfield wastewater, Automatic control, Coarse granulation, Internal circulation backwashing*

1. Introduction

With the rapid development of China’s national economy, oil fields have gradually entered the middle and late stages of exploitation. The water content in the produced oil is as high as 70%-80%. Due to the amount of oily wastewater is large, if it is directly discharged without treatment, it will not only Cause serious environmental pollution, but also harm the interests of the oilfield itself; if the treated oilfield wastewater is reinjected, it can not only reduce environmental pollution, but also conform to the oilfield's own interests and the national sustainable development strategy.

At present, most oilfields use coarse-graining reactors that perform intermittent backwashing after the long-term coarse-graining stops. It is difficult to effectively backwash the oily particles, suspended solids and other impurities adhering to the packing by using this device, and it is time-consuming and water-consuming, which causes the treatment to stop and perform backwashing during operation. The substantial increase in cost has brought about a huge economic burden to the petrol station. Cooperated by Wuhan University of Technology and Shandong Aluminum

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Company, based on the mechanism of “collision coalescence [1]” and the internal circulation continuous flow backwashing, the internal circulation coarse-grained reactor was developed and designed in the laboratory. On the basis of the raw water simulation coarse-grained experiment, the oil-bearing wastewater from the Jianghan Oilfield was tested.

2. Controlling Design Principle

The internal circulation coarse-grained reactor was developed in cooperation with Wuhan University of Technology and Shandong Aluminum Company. The entire coarse-grained tank is cylindrical and uses upward flow.The oil field wastewater enters the bottom of the tank through the water inlet pump, distributes the water evenly through the water distribution system, and enters the packing layer. The coarse-grained bed composed of oleophobic ceramic filter materials, the gaps of which form mutually continuous channels, such as countless small diameters, crooked and staggered of microtubules. When the oily sewage flows through the bed, because the coarse graining material is oleophobic, two or more oil droplets may collide with the pipe wall or each other at the same time, and their impulse is sufficient to make them merge into a larger oil droplets, so as to achieve the purpose of coarse-graining, and then the enlarged oil droplets get rid of the constraints of the filler under the action of hydraulic force, and float to the water surface to be removed.

Back flush part: When the impurity content of the packing layer reaches a certain level, the coarse-graining function of the packing layer will become worse and worse, reaching its breaking point at a certain moment. At this time, the back flush water pump is turned on to remove the clean water in the water tank. The bottom of the tank is pumped into the tank for back flush. The high pressure water from the back flush inlet pipe forms a negative pressure zone between the nozzle and the riser, so that the filter material at the bottom of the riser is pressed into the riser, and the filler on the outside of the tube slides continuously to the bottom of the riser along the slope, and enters the riser with the high-pressure water. The filler that enters the riser collides and rubs violently in the tube to remove the impurities attached to the particle surface, and then the filler slides to the bottom of the riser through the umbrella cover. The top of the filler layer, so that the filler layer has to be updated [2]. This is the internal circulation back flush.

The feature of this device is that it adopts continuous operation of inlet and outlet water and intermittent operation of single water backwash system, which makes it compact in structure and convenient in operation and management. Taking into account the water quality characteristics of oily wastewater with relatively high viscosity, the biggest feature of this coarse-graining process is to strengthen the back flush effect of the filter material through the reasonable design of the internal structure of the tank, that is, the use of stepwise back flush in this way, the operation mode of “filtering can be continued while back flush is realized, and the processing capacity of the entire device is improved. At the same time, because the filter layer

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is washed successively, the energy consumption utilization rate and the backwash effect of the back flush are greatly improved.

3. Materials and Devices

3.1 Device

The reactor volume of the pilot dynamic test is about 0.5m3, the height is 2.55m, the thickness of the filter layer is 700mm, and the middle riser is an internal circulation backwashing pipe. The incoming water in the original pool is lifted by the pressure pump, enters from the bottom of the reactor, enters the reactor through the water distribution grid, and the coarse-grained effluent is discharged from the upper water outlet. The back flush water comes from the water storage tank, the clean water enters the internal circulation reactor through the backwash pump, and the back flush water is discharged from the drain tank. The device is shown in Figure 1.

Regarding automatic control, a PLC control system based on feedforward compensation is adopted to improve the quality of oily wastewater treatment and reduce oil waste. Compared with PID control based on feedback control, feedforward compensation control can control the start and stop of the backwash pump in advance according to the time lag characteristics of the device, which can ensure the treatment quality of oily wastewater and improve the utilization rate of oily wastewater.

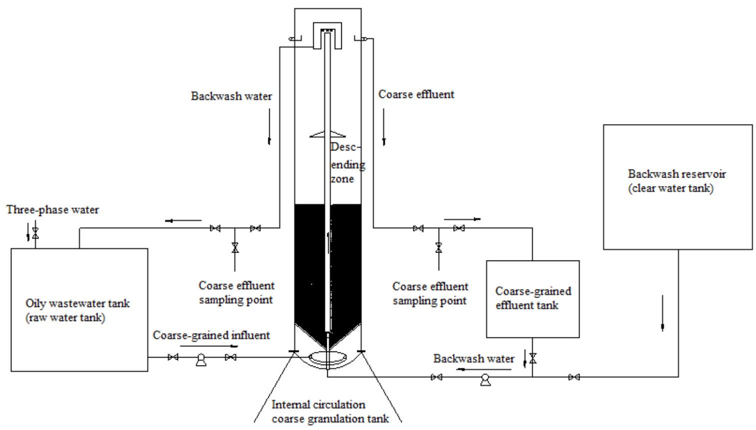

Fig.1 Schematic Diagram of the Device

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3.2 Selection of Raw Water Samples

Selection of laboratory raw water: add a certain amount of aged soil to tap water and configure it to simulate raw water with a turbidity of 20-30NTU.

Selection of the raw water for the pilot test: The oily wastewater from the two sewage storage tanks of Jianghan Oilfield Oil Production Team 22 (the second station) is a mixed wastewater composed of oilfield oil production wastewater and oily wastewater separated from the three-phase separator. The oil content of this oily wastewater is not high, but the suspended solids content is high, the particles are fine, and it contains a certain amount of iron salts and other inorganic salts.

3.3 Reagents and Instruments

Reagents: analytical pure CCl4, anhydrous NaSO4;

Instrument: TDT-2 turbidity meter produced by Wuhan Hengling Technology Co., Ltd.,The model produced by Jilin Beiguang Analytical Instrument Factory is JDS-106U infrared spectrophotometer and its supporting jet extractor.

4. Results and Analysis

4.1 Coarse-Grained Simulation Test in Laboratory

a. Test conditions

The filler in the internal circulation coarse-grained reactor is a new environmentally friendly ceramic filter material developed by the School of Materials of Wuhan University of Technology [3], the particle size of the filler is 1.6-2.0mm, the color is red, and the thickness of the filler is 700mm. The raw water is the raw water configured under laboratory conditions. The turbidity of the raw water is 24.59NTU, the dosage of PAC is 15mg/L, and the rising flow rate is 2m/h. By comparing and analyzing the turbidity of the effluent of the coarse-grained outlet pipe and its removal rate, it is found that the turbidity of the effluent has been kept below 1NTU during the operation time, and the turbidity removal rate is as high as 98%.

b. The influence of internal circulation backwashing on the coarse granulation process

Through observation, when the color of the filler at the bottom of the filler layer changes from red to yellow, the backwash water pump is turned on to start backwashing, that is, the internal circulation backwashing starts synchronously 4 hours after the start of coarse-graining and turbidity removal. Through this step, the effect of backwashing on the effect of coarse-grained turbidity removal under the conditions of simultaneous coarse-grained simulated turbidity removal and internal circulation backwashing is detected, and the turbidity of the coarse-grained effluent

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and backwash effluent is taken as Judgment criteria to determine the time for the filter layer to achieve overall back flush.

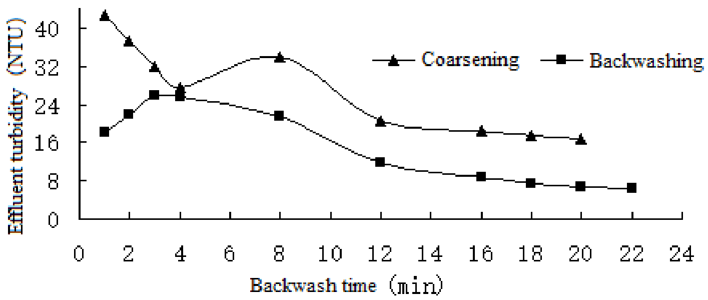

Fig.2 Influence of Internal Circulation Back Flush on Coarse Graining

It can be seen from the figure that the coarse-graining and turbidity removal are carried out simultaneously with the internal circulation backwashing. In the first few minutes, the coarse-graining effect is greatly affected by the backwashing. This effect gradually disappears in about 20 minutes, and the coarse-grained effluent turbidity tends to be stable, and it can be inferred that the filling time for backwashing is about 20min.

4.2 Pilot Test of Oilfield Wastewater Treatment

The test device is the same as the above, the raw water uses the oily wastewater from the 22 oil production station of Jianghan Oilfield, and the coarse-grained water inlet flow rate is 2-5m/h. In this step of the test, the oil content and turbidity of the coarse-grained effluent are measured respectively, and the oil and turbidity removal rate of the wastewater from the pilot plant is calculated to determine the oil removal cycle and suspended matter removal cycle of the device.

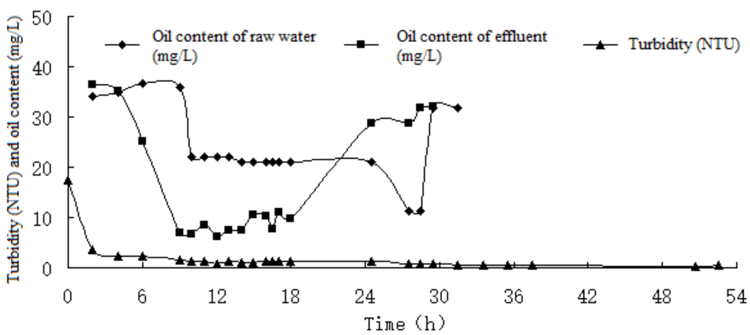

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Fig.3 Curve of Oil Content and Turbidity of Coarse-Grained Effluent

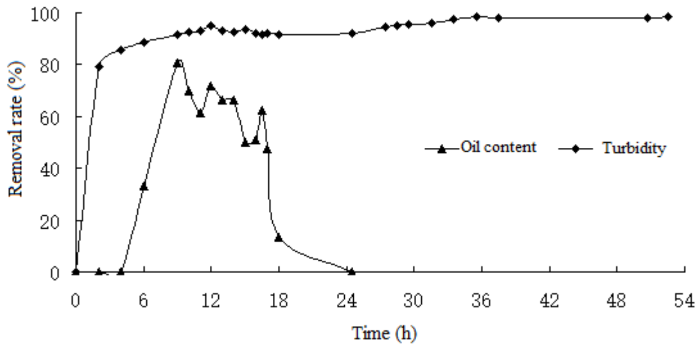

Fig.4 Curve of Oil and Turbidity Removal Rate

From the above two figures, it can be seen that the failure point of the oil removal of the pilot plant is about 22h. After this, the oil content in the coarse-grained effluent water is almost equal to the oil content in the influent water, or the effluent water starts to be higher than the influent water. At this time, internal circulation backwashing can be carried out; during the operation of the pilot plant, the turbidity of the coarse-grained effluent is relatively stable, and the fluctuation is very small within the monitored 53h, and the maturity period of degreasing and deturbidity is not consistent The maturity period for turbidity removal ends at about 2h. After that, the turbidity of the effluent is lower than 3NTU and tends to be stable. The maturity period for degreasing ends at about 8h. At this time, the oil content of the effluent starts to fall 10mg/L, but the duration of maintaining a large oil removal rate (above 50%) is only 10h, and the suspended matter removal rate has always remained high and very stable. It can be seen that the turbidity removal cycle is better than the oil removal The cycle is much longer; under the condition that the pilot plant maintains a high oil and turbidity removal rate, the average removal rate of oil is as high as 50%, and the average removal rate of suspended matter is as high as 95%.

5. Conclusion

(1) The use of internal circulation backwashing can reduce the energy and time consumption of conventional backwashing, thereby effectively increasing the water production per unit time and reducing treatment costs;

(2) The effective control time of backwashing the packing layer with the pilot plant in this article is 20 minutes, and the largest interference to the coarse-graining effect is concentrated in the first few minutes;

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(3) Through the pilot test, it is found that the oil removal cycle is about 22h, and the high oil removal period starts from the 8th hour, and the oil removal rate is relatively stable and maintains a high oil removal rate for the next 10h, with an average value of up to 50%. The turbidity period is longer than 53h, and its high-efficiency period starts from the 2nd hour and has been very stable since then, with an average value of 95%.

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