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Research on Integrated and High Efficient Oily Water Treatment Automatic-Controlling Equipment

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ABSTRACT. *'To achieve the high quality requirement for the injected water in exploiting low-permeability oil field, the integrated and high efficiency oily water treatment equipment had been designed. Based on the analysis of the existing oilfield oil-containing wastewater treatment process, using T-S fuzzy neural system to iterate and optimize operating parameters, the design idea of an integrated high-efficiency oil removal device was expounded, and field experiment research was carried out. The results show that the effluent quality of the integrated high-efficiency oil removal device could meet the A1 standard in the National "Recommended Water Quality Index for Reservoir Injection" SY/T5329-94.It is at the leading level of technology in China and has the advantages of simple process, high pollution removal efficiency, good regeneration effect and high degree of automation.*

KEYWORDS: *Oily water treatment automatic control, Re-injection, Flocculation, Multi-filtration*

1. Introduction

With the rapid development of my country's economy, the pressure onenergy and the environment is increasing, especially the dependence on non-renewable energy sources such as petroleum. Therefore, while giving priority to the development of these industries, it has also brought tremendous pressure to the environment for people to live. Water, atmosphere, and soil have been polluted to varying degrees, which has damaged the ecological balance to varying degrees, which is not conducive to the rapid, healthy and sustainable development of the national economy.Especially for oilfield mining companies, after the oilfield development enters the middle and late stages, the pressure of the oil layer drops greatly, and water injection and oil recovery is an important means to maintain the pressure of the oil layer. After the extracted crude oil is dehydrated, the water generally contains

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a certain amount of oil, sulfide, organic phenol, cyanide, bacteria, solid particles, and added chemical agents such as demulsifies, flocculants, and fungicides. The discharge of a large amount of produced water not only causes serious pollution to the environment, but also wastes precious water resources. Therefore, under the condition that the country advocates energy saving and emission reduction, how to solve the large amount of oily wastewater generated in the oil extraction process and ensure the sustainable development of oil fields has become a very urgent task. For this reason, we have developed an efficient oily wastewater treatment device and applied it to the actual oilfield oily wastewater treatment. After the treatment, the effluent reached A1 in the “Recommended Water Quality Index for Rock Reservoir Injection” SY/T5329-94 standard. The use of effluent for re-injection not only avoids environmental pollution, but also improves the economic benefits of the oilfield.

2. Characteristics of Oil-Bearing Wastewater from Oilfields and Its Treatment Status

2.1 Characteristics of Oily Wastewater from Oilfields

Due to the differences in the geological conditions, development methods, oil reservoir reform measures, water injection quality, gathering and transportation technology of various oil fields in China, the nature of oil production wastewater varies greatly from oil fields. In addition, the mixing of other sewage (such as well washing sewage, transfer well sewage, domestic sewage, etc.) in the oil field makes the composition of oil production sewage more complicated. Generally speaking, it has the following characteristics:

(1) High oil content. Generally, oil production wastewater contains 1000~2000mg/l of crude oil, and some oil content can reach 5000mg/l. The existence of oil in water can be divided into slick oil, mechanically dispersed oil, emulsified oil, dissolved oil and attached oil according to the size of oil-containing particles.

(2) Contain suspended solid particles. The particle size is generally 1-100μm, mainly including clay particles, silt sand and fine sand.

(3) High salt content. Generally, the content of inorganic salt in oilfield wastewater is very high, ranging from several thousand to several ten thousand or even several hundred thousand mg/l, which varies from oil field to block and oil layer. Inorganic salt ions mainly include: Ca2+,Mg2+,K+,Na+,Fe2+,Cl-,HCO3-,CO32- etc.

(4) Contains bacteria. Mainly saprophytes and sulfate reducing bacteria.

(5) Some oilfield sewage contains surfactants. It mainly exists in tertiary oil recovery polymer flooding fields in my country.

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2.2 Current Status of Oilfield Wastewater Treatment

At present, many oily wastewater treatment technologies studied abroad include: membrane separation technology, hydro cyclone technology and ultrasonic technology. Although some of these technologies can achieve relatively good processing results, they cannot be widely used due to the small processing volume, high cost, and complex management. The choice of methods and processes for treating oily wastewater in China varies according to the composition of the wastewater, the form of oil, and the degree of recycling. The oil separation-air flotation-biochemical process is more common, and coagulation-air flotation-filtration processes are also used. However, these treatment methods have a long process, high investment costs, and unstable effluent quality, thus failing to achieve discharge. standard.

3. Design Idea of Integrated High-Efficiency Oil Removal Device

For the purpose of re-injection after treatment of oily wastewater, a new type of ceramic water purification material with independent intellectual property rights jointly developed by Wuhan University of Technology and Shandong Aluminum Company is used to design a set of integrated high-efficiency removal equipment for oilfield oily wastewater treatment requirements. Oil device. First, according to the principle of the hydraulic circulation clarifier, an efficient settling tank that integrates “demulsification-coagulation-sedimentation” is designed and used as a pretreatment equipment, and then a coarse-grained material is used to design a settling tank The internal circulation coarse granulation tank is finally combined with the multi-stage fine filter tank to form a combined treatment process of “demulsification coagulation-coarse granulation-multi-stage fine filtration”.

For the first time in China, the demulsified coagulation tank applied the principle of “contact enhanced adsorption flocculation” to form an active oil slag layer at the bottom of the demulsified coagulation tank, making full use of the flocculation of the bottom active mud slag. The coarse granulated tank adopts the operation mode of oil-sparing ceramic filter material, upward flow filtration and internal circulation backwash, which not only improves the regeneration ability of ceramic filter material, but also greatly increases the sewage interception ability of filter layer. At the same time, it also effectively reduces the operating energy consumption. The oil-friendly ceramic filter material with large specific surface area is selected for multistage fine filtration. Compared with the traditional filter material such as quartz sand, the new ceramic filter material has the outstanding characteristics of strong sewage interception ability, long filtration period and good effluent effect. and has been successfully applied in Hubei Xiaogan Water Company, Shandong Lumei Silk Industry Co., Ltd. Based on the principle of “reverse granularity filtration” and “multi-layer filter material filtration “, a set of multi-stage fine filter device is designed, which is arranged symmetrically, each part is 3 segments, each segment adopts the same gradation homogeneous filter material. But on the whole, the whole filter layer is more uniform. At the same time, the closed pressure filter can not only

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guarantee the water pressure, but also make the filter material get sufficient backwash and save energy consumption.

4. Content of Field Experiment

The field experiment of the integrated high efficiency deoiling device is carried out at the oil production station under Jianghan Oilfield Oil production Plant. The main water quality indexes of the effluent are tested and analyzed. In order to correctly evaluate and determine the performance and optimal operating parameters of the integrated high efficiency deoiling device.

According to the data collection conditions of the integrated device, a T-S fuzzy neural control system with learning ability is designed to perform refined management of backwash time and pump flow. Through iterating the data of the existing operating conditions, the system has the ability of coordinated control for complex operating points, and the rapidity and robustness of the control system are improved.

4.1 Original Conditions of the Experiment

According to the actual situation of the station, We connect the integrated high-efficiency oil removal device to the existing pipeline system, the technological process is as follows: three-phase separator → 100m3/200m3 buffer tank → Integrated high-efficiency oil removal device and water injection tank. As a result of many factors, The influent water quality of the integrated high efficiency defiling device varies greatly, Flow control m3/h.The backwash comes from deep underground well water on the station, The iron content is high, a preliminary determination of up to 15 mg/l. The added agents include alkali (30% NaOH solution) and flocculant (solid PAC), NaOH solution is taken directly from the liquid alkali storage tank on the station, solid state PAC purchased directly from the market.

4.2 Test Items, Methods and Instruments

(1) Determination of oil content in inlet and outlet water: determination of oil by infrared spectrophotometer of JDS-106U type produced by Beiguang Analytical Instrument Factory of Jilin City.

(2) Determination of turbidity (SS): HACH 2100P portable turbidimeter was used for determination.

(3)Determination of total iron content: determination by phenanthroline spectrophotometry.

(4) Measurement of flow rate: on-line measurement using a screw-wing water meter.

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4.3 Content of the Experiment

After the integrated and efficient deoiling device arrives at the site of the oil production station, the connection between the pipeline and the pipeline in the station and the automatic control system and the installation of the instrument are completed. Then the test run is carried out, including adjusting the liquid level and flow rate of the tank, cleaning the tank and filter material, etc., to prepare for the formal operation behind.

4.3.1 Joint Operation Experiment

Control effluent flow m3/h,10 The effluent ph is between 8.5~9.0, When the dosage pac(10%) flocculant is 10 l/h, Intermittent 3 days, 6~8 hours a day, Every 30 min, Determination of turbidity ss, oil content and total iron content of effluent. The experimental results are shown in Table 1,2,3. We can see clearly from the data in the table, The integrated and efficient oil removal device can remove the impurities such as suspended matter in oil-bearing wastewater, And the turbidity of the effluent is below 1 mg/l, Has reached the national a1 standard. At first, the turbidity of the effluent was higher because the residual impurities in the tank were gradually cleaned out of the tank and the filter material was still in the mature stage, But with the increase of HRT, The turbidity of the effluent decreased obviously. Even when the suspended matter in raw water is over 60 mg/l, The effluent is still up to standard, Reflects a strong impact load resistance. And the oil content of the effluent can be controlled well below 5 mg/l, Has reached national a1 standards, And the oil content of the effluent does not increase obviously with the increase of the flow rate. When the total iron content of the effluent is between 8.5~9.0, Can be controlled below 0.5 mg/l, And the total iron content of the effluent does not increase obviously with the increase of the flow rate. As the tank is not embalmed, At the same time, the iron content in raw water is very high, So you have to keep the ph between 8.5~9.0, Thus reducing the corrosion of the tank and controlling the total iron content of the effluent. So assuming the tank is embalmed, And the ph value of the water is within 7.5, (b) Total iron content in effluent remains below mg/l,0.1 And reach the national a1 standards. This fully reflects the obvious advantages of the integrated and efficient oil removal device in removing iron and its compounds.

4.3.2 Experiment of Single Tank Treatment

In order to better measure the performance and regularity of integrated and efficient deoiling device, To characterize the treatment law and effect of demulsifying coagulation tank, coarse granulation tank and multistage fine tank, To provide a reference for further improving the treatment effect of integrated and efficient oil removal device, The treatment effect of each tank is tested. Flow is still controlled m3/h,10 The effluent ph is between 8.5~9.0, When the dosage pac(10%) flocculant is 10 l/h, Intermittent 3 days, 6~8 hours a day, Every 30 min, Determination of turbidity ss, oil content and total iron content of effluent. The experimental results are shown in Table 4,5,6,7,8,9,10,11,12.

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4.3.3 Experiment of Backwashing Effect

As the core treatment equipment of integrated and efficient oil removal device: coarse granulation tank and multistage fine filtration tank, they play an important role in removing suspended matter and oil in oily wastewater. Therefore, they should not only have the ability to remove pollutants from wastewater efficiently, but also be easy to regenerate and recycle. This involves the backwashing and regeneration of filter media. The original turbidity is 6.90 ntu, the oil content is 0.8 mg/l.. The groundwater in deep well is used as backwashing source The coarse granulation tank adopts the combined operation mode of internal circulation backwashing and integral backwashing, while the multistage fine filter tank adopts the way of backwashing one by one of the six silo bodies. The experimental results are shown in Table 13,14.

Table 1 Turbidity Removal Law of Joint Operationunit: Ntu

Number	1	2	3	4	5	6	7	8	9
Raw water	12.80	11.20	10.90	12.00	12.50	10.00	12.00	11.00	10.80
Effluent	1.02	2.18	2.38	1.77	0.51	0.59	0.49	0.33	0.23
Number	10	11	12	13	14				
Raw water	11.20	14.20	37.30	64.90	14.80				
Effluent	0.29	0.40	0.47	0.36	0.71				

Table 2 Oil Removal Rule of Joint Operation Unit: Mg/l

Number	1	2	3	4	5	6	7	8	9
Raw water	23.910	20.713	17.854	13.985	17.257	12.896	12.358	16.496	15.528
Effluent	1.621	4.138	5.186	4.935	3.391	3.931	3.437	3.554	4.766
Number	10	11	12	13	14				
Raw water	16.476	62.963	14.596	18.153	13.906				
Effluent	3.546	3.791	1.426	4.136	4.552				

Table 3 Law of Total Iron Removal in Combined Operationunit: Mg/l

Number	1	2	3	4	5	6	7	8	9
Raw water	17.29	24.99	22.09	17.50	35.59	36.71	27.67	7.83	7.40
Effluent	1.31	0.56	0.50	0.28	0.19	1.72	2.13	8.18	8.66

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Number	10	11	12	13	14				
Raw water	7.79	7.35	6.73	6.65	6.75				
Effluent	8.46	8.98	9.51	9.18	8.14				

Table 4 Turbidity Removal Rule of Demulsification Coagulation Tank Unit: Ntu

Number	1	2	3	4	5	6	7
Raw water	12.80	10.90	12.50	12.00	10.80	14.20	64.90
Effluent	55.70	16.50	23.30	20.90	19.50	14.30	31.90

Table 5 the Law Of Oil Removal in Demulsification Coagulation Tank Unit: Mg/l

Number	1	2	3	4	5	6	7
Raw water	23.910	17.854	17.257	12.358	15.528	62.963	18.153
Effluent	9.895	12.370	9.338	16.496	26.051	14.383	12.673

Table 6 Total Iron Removal Law of Demulsification Coagulation Tank Unit: Mg/l

Number	1	2	3	4	5	6	7
Raw water	7.83	7.40	7.79	7.35	6.73	6.65	6.75
Effluent	8.68	9.07	9.50	9.31	8.35	8.30	8.41

Table 7 Turbidity Removal Law of Coarse-Grained Tank Unit: Ntu

Number	1	2	3	4	5	6	7
Raw water	12.80	10.90	12.50	12.00	10.80	14.20	64.90
Effluent	25.80	14.60	8.86	10.60	11.40	9.79	9.62

Table 8 Oil Removal Rule of Coarse-Grained Tank Unit: Mg/l

Number	1	2	3	4	5	6	7
Raw water	23.910	17.854	17.257	12.358	15.528	62.963	18.153
Effluent	12.795	15.831	8.090	29.618	15.018	8.921	10.491

Table 9 Law of Total Iron Removal in Coarse-Grained Tank Unit: Mg/l

Number	1	2	3	4	5	6	7
Raw water	7.83	7.40	7.79	7.35	6.73	6.65	6.75
Effluent	8.75	8.50	9.10	9.42	9.10	8.80	9.20

Table 10 Turbidity Removal Law of Multistage Fine Filter Tank Unit: Ntu

Number	1	2	3	4	5	6	7

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Raw water	12.80	10.90	12.50	12.00	10.80	14.20	64.90
Effluent	1.02	2.38	0.51	0.49	0.23	0.40	0.36

Table 11 Oil Removal Law of Multi-Stage Fine Filter Tank Unit: Mg/l

Number	1	2	3	4	5	6	7
Raw water	23.910	17.854	17.257	12.358	15.528	62.963	18.153
Effluent	1.621	5.186	3.391	3.437	4.766	3.791	4.136

Table 12 Total Iron Removal Law of Multistage Fine Filter Tank Unit: Mg/l

Number	1	2	3	4	5	6	7
Raw water	7.83	7.40	7.79	7.35	6.73	6.65	6.75
Effluent	8.18	8.66	8.46	8.98	9.51	9.18	8.14

Table 13 Coarse Granulation Tank Backwashing Law

	Inner loop 1		Inner loop 2		Inner loop 3	
	first	5min	first	5min	first	5min
Turbidity(NTU)	*	26.90	*	66.80	*	56.40
Oil(mg/l)	*	13.317	*	10.877	*	4.980
	Overall backwash					
	first	6min	8min	10min		
Turbidity(NTU)	*	527.00	42.70	44.50		
Oil(mg/l)	*	272.086	119.023	20.952		

Note: The symbol "*" means that the measured value exceeds the measuring range of the instrument.

Table 14 Backwashing Regularity of Multi-Stage Fine Filter Tank

	West 1 warehouse		West 2 warehouse		West 3 warehouse	
	first	4min	first	3min	first	5min
Turbidity(NTU)	250.00	13.50	78.90	12.30	112.00	9.48
Oil(mg/l)	41.250	8.514	43.228	14.785	26.529	7.585
	East 1 warehouse		East 12warehouse		East 3 warehouse	
	first	4min	first	3min	first	5min
Turbidity(NTU)	275.00	13.40	33.00	10.20	26.10	14.70
Oil(mg/l)	126.428	13.697	31.117	9.708	7.633	2.615

5. Results and Discussion

Through the field experiment of the integrated high efficiency oil removal device above, it can be seen that under the condition that the raw water quality changes greatly and the daily treatment capacity is 240 m3/d, The main indexes of effluent

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quality of this process have reached the A1 standard in the SY/T5329-94 of "recommended index of water quality in clastic rock reservoir ", which reflects the leading level in China. Compared with the existing domestic oil field wastewater treatment process, it has the following advantages:

(1) The excellent effluent quality. This is the most remarkable feature of this device. As can be seen from tables 1,2 and 3, the main technical indexes of effluent (turbidity, oil content and total iron) have reached the national a1 standard, It is difficult to achieve the treatment process of oily wastewater in many oil fields, It reflects the domestic leading level of this process in exploring oil field oily wastewater treatment process, It lays a solid foundation for further optimization and improvement of oily wastewater treatment process in oil fields.

(2) Strong resistance to impact loads, High pollutant removal efficiency. The oily wastewater of oil field is complicated, It's hard to control, This requires that the treatment device has good impact resistance, Ensure the effluent quality is up to standard discharge. Through the joint operation experiment, The device has a multistage fine filter tank as the final barrier, If the turbidity of raw water is over 60 mg/l, The effluent can still reach the standard. It can be seen from tables 4,7 and 10 that the turbidity removal rate is over 90%, thus ensuring that the turbidity of the effluent is below 1.0 mg/l. In addition, the oil content in the effluent of the device can basically meet the standard, And will not change significantly with the flow, It can be seen from Table 5 and 11 that demulsified coagulation tank and multistage fine filtration tank play a vital role. It can be seen from Table 3 that the content of iron in the effluent is not fully up to standard, But when the iron content in raw water is more than 15 mg/l and the tank is not anticorrosive, When the ph value of the effluent is between 8.5~9.0, Ferrite content less than 0.5 mg/l, Having met national a1 standards, The removal rate is as high as 95% or more.

(3) Good regeneration, low water consumption and low energy consumption. Because the treatment process adopts the latest structural design, the backwash regeneration method is unique, especially the coarse granulation device adopts the internal circulation backwash mode, which realizes the operation mode of simultaneous filtration and backwash, thus improving the processing ability of the device. It can be seen from Table 13 that the regeneration effect of filter material after successive cleaning is very good, which greatly reduces water consumption and energy consumption. The multistage fine filtration device adopts the large resistance water distribution system, and the backwashing mode is carried out one by one, which makes the multistage fine filtration device as the final barrier get a good regeneration. It can be seen from Table 14 that the pollution interception of the first stage of the multistage fine filtration device is much higher than that of the second and third stages, which is different from the function of the gradation and function of the filter material. Because the multistage fine filtration device adopts symmetrical arrangement, the filtration and backwashing can be carried out simultaneously, thus realizing the continuity characteristics of the operation of the integrated and efficient oil removal device.

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(4) High degree of automation and ease of operation. According to the continuous monitoring of the on-line turbidimeter, the dosage is automatically controlled, whether backwashing is needed or not, and the liquid level of the demulsified coagulation tank and the coarse granulation tank and the frequency of the original water pump and the pressurized pump are automatically controlled according to the continuous monitoring of the on-line liquid level meter, thus greatly improving the working efficiency and treatment effect.

(5) The process is simple, small and mobile. Because of its compact structure and high degree of automation, the device can be installed on trucks to realize the mobility and assembly of the whole device. It can be easily transported to various major oil fields and petrochemical enterprises in China for the treatment of oily wastewater on the spot. It provides a good solution for solving the problem of oily wastewater treatment in China.

In a word, the development and application of integrated and efficient oil removal device is the first new type of oil removal device with independent intellectual property rights in China, and it is a technological revolution in oil removal equipment and technology in the past. Its successful application in oil fields and petrochemical enterprises will bring about great economic, social and environmental benefits to local people.

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