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Research on the Fine Filter Cleaning and Regeneration Process of Polluted Filter

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Abstract: The filter's performance and characteristics in the interception process of oilfield wastewater treatment were analyzed and discussed. Through filter material composition and pollutant analysis, the experiment optimizes the high-efficiency regeneration detergent reagent and formula of pollution filter material and studies the effects of stripping and bactericidal properties of surfactant compound. Static immersion experiments of the polluted filter material (oil sand) show oil wash rate of 91.4%. The mass spectrometry was carried out to analyze components of filter and contaminants and so was the scanning electron microscopy to compare the surface of unused media and contaminated media. It could be seen that the appearances are in sheet structure, which is the structural characteristics of SiO_2, and the one for contaminated media is a large number of flocculent organic matters. Field test data show that the water oil content after the filtration reduces from 2.95 mg/L to 0 mg/L, suspended solid content from 18.25 mg/L to 5.8 mg/L. The water quality improves significantly.

Keywords filter; oil field; wastewater; regeneration; surfactant

INTRODUCTION

Oilfield wastewater includes oilfield produced water, drilling wastewater and other types of oily wastewater. Treatment methods of oil sewage can be summarized as physical, chemical and biochemical, among which membrane separation, magnetic adsorption separation and advanced oxidation are hot spots in current research and application[1]. Water treatment process of Daqing oilfield low permeability reservoir (permeability of $20\times10^{-3}\mu m^2$-$100\times10^{-3}\mu m^2$) is a kind of subtle filtration, which uses a terminal protection technology basically by applying fiber filters, multi-layered sand filter small particles (0.25-0.5mm), etc. Water quality can be achieved in low permeability reservoir injection water standard indicators (People's Republic of China Oil and Gas Industry Standards SY/T5329-94). However, as far as ultra-low permeability reservoir (less than $20\times10^{-3}\mu m^2$) is concerned， water quality requires to achieve oil content ≤ 5mg / L, suspended solid content ≤ 1mg / L and the median particle size of suspended solids ≤ 1μ m". Currently, the separation membrane technology with high precision is used in oil field fine filtering [2, 3]. The technology can achieve water standard indicators of ultra-low permeability reservoir injection in water filtration performance, but there are some problems in aspects of equipment operating costs and reducing management difficulty. Thus based on technical and economic considerations, fine filtration process is suitable for the production and management of water quality precision process.

MATERIALS AND METHODS

Compatibility of tiny fine particle filter

Physical and chemical properties of filter are shown in Table 1-3. In the light of the physical and chemical properties and the advantages of various media, emery was used as filter, quartz sand or magnetite used as cushion and gravel the supporting layer.

The selection results: Emery filter is of d = 0.10~0.20 mm, magnetite and quartz sand d = 0.25 ~ 0.50 mm.

Table 1 The physical and chemical properties of emery filter

Analysis Item	Test Data	Analysis Item	Test Data
Capacityg/cm^3	2.7	Porosity%	48
Fe_2O_3	29.80%	Hardness °	7.5—7.9
Proportion g/cm^3	4.0	Melting℃	1313—1318
SiO_2	36.60%	CaO	4.85%
AL_2O_3	20.29%	TiO_2	2%
MgO	7%	Garnet content	>85%

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Table 2 Physical and chemical propertiesof quartz sand

Analysis Item	Test data	Analysis Item	Test data
Proportiong /cm^3	2.66	Boiling point(℃)	2550
Densityg/c m^3	1.85	Hydrochlo ric acid soluble rate(%)	≤3.0
Broken rate%	0.53	Acid resistance(%)	98
The wear rate%	0.38	Melting(℃)	1480
Porosity%	43-47	SiO_2(%)	≥98
Mohs hardness	6.0—7.5	Ca(%)	0.02

Table 3 Physical and chemical properties of magnetite media

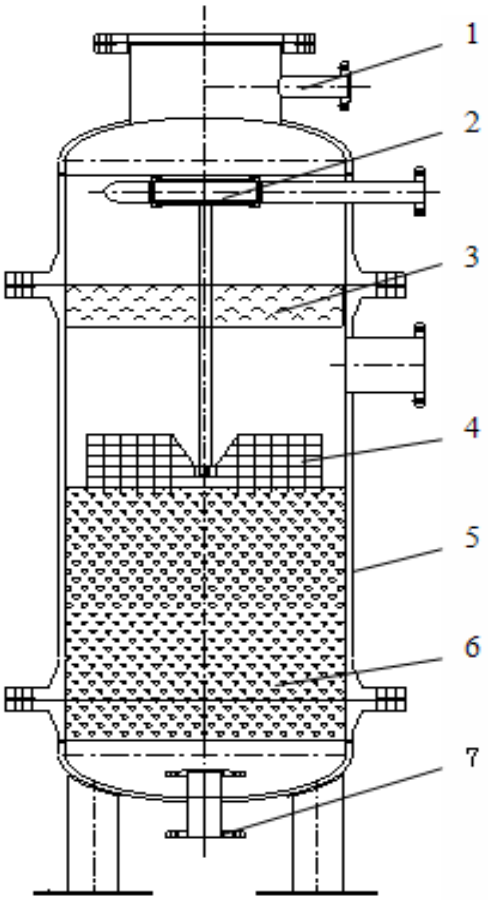
Analysis Item	Test data	Analysis Item	Test data
Proportiong/c m^3	4.6	Broken rate	0.05%
FeO_2	40%	Mohs hardness	6
Bulk densityg/cm^3	2.6-2.8	Clay content	≤2%
Uniformity coefficient	K80≤1.8	Porosity	47%

Filter structure configuration

The filter layer is composed of tiny mixed media, of which the bigger surface area, smaller holes and suitable filter thickness can guarantee the high filtration precision. As the resilience and stability of tiny filter layer means long-term stable operation, aiming at the difficulty for backwashing and regeneration issues and the loss of small filter, filter tank is designed with dual backwash, elimination energy panels and three-dimensional grid mixer. The design of the canister structure was shown in Figure 1.

RESULTS AND DISCUSSION

The continuous filter holds back pollutantin process of oily wastewater treatment. Because of contaminants adhering to the filter surface, the filter capacity and backwashing effect were reduced. If this process continues for a sufficient time the filter will behardened orscrapped [4]. reduces adhesion and filtration media channels. Therefore,In terms ofthe canister, the dirt holding



1 Sewer；2 Inlet pipe；3 Dampers；4 Stirrer；5 Tank；6 Filter media ； 7 Inlet pipe

Figure 1 Schematic diagram of the filter structure

Thesurvey on the current water quality of sewage treatment station findings show that: the filter's pollution is significantly worsening in Daqing oil field, which mainly appears as filter dirt holding capacity decreases significantly by deteriorated water quality after filtration, backwash energy consumption increases and backwash effect reduces.The main reasons for increaseof filter pollution are: First, with the extension of oilfield , the content of oil and suspended solids are increasing in water waste, which accelerate the pollution of filter. In order to discharge oily wastewater, Daqing oilfield requires to annually purchasetons of quartz sand, gravel, walnut shell filter , most of which is used to replace contaminatedmedia. Therefore, it is necessary to cleanfilter pollution so that it can be regenerated, extend its life and reduce the environmental pollution. However, it is difficult to make the contaminated filter regeneration only through the conventional backwash process. Sothe filter cleaning technology for actual production is of urgent need [5].

Media composition and contaminant analysis

The mass spectrometry analysis is given in Figure 2, sample is cyclohexane immersed oil sands, the

results show that the adsorbed species of oil sand are organic mixtures, which are alkane, alkyl aromatics, naphthenes, polycyclic aromatic hydrocarbons and other petroleum-based organic matters. MS analysis shows that the sand's adsorptionsare main components of crude oil.

Scanning electron microscopy (SEM) observations were obtained using a model Hitachis-570 microscope, operating at 20Kv. The SEM were carried out to compare the appearance.

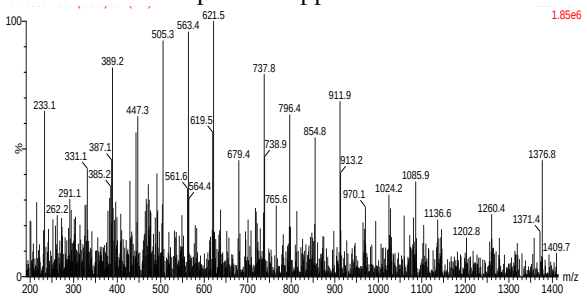


Fig.2 the result of Mass Spectrometry

Figure 3 and Figure 4 show the typical results of SEM for unused media (Figure 3) and for contaminated media (Figure 4), it could be seen that theappearances were sheet structure, which were structural characteristics of SiO_2, and the one for contaminated media wasa large number of flocculent organic matters.

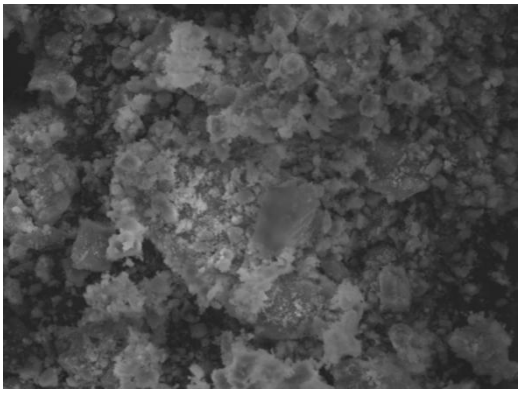


Fig.3 SEM micrographs of unused media

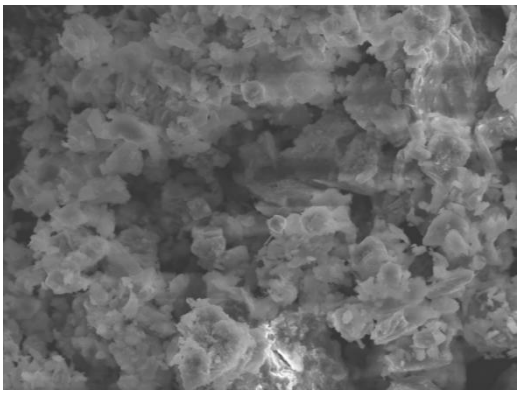


Fig.4 SEM micrographs of polluted media

Table 4 the component of Oil Sands and sands

Oxide	K_2O	Na_2O	CaO	MgO	Fe_2O_3	SrO
Sand	0.07	0.05	0.28	0.02	0.19	0.005
Oil sands	0.08	0.09	0.50	0.03	0.30	0.005
Oxide	Al_2O_3	BaO	ZnO	SiO_2	Weightlessness	
Sand	0.30	0.01	0.001	98.00	0.95	
Oilsands	0.70	0.08	0.004	98.00	0.54	

Inductively coupled plasma emission spectroscopy (ICP) for contaminated filter and new media were shown in Table 4. The results show that the contaminated media (oil sands) and new media components are SiO_2. The filter contamination of the sample contains a relatively large CaO, Fe_2O_3 and Al_2O_3.

The above analysis data show that the main pollutants for sand are oil, $CaCO_3$, and large amounts of bacteria.

the development of Efficient filter cleaning agent LD-1

According to the analysis of filter pollutants ingredients, the major component of filter pollutants is crude oil, so the cleaning agent containing chemical agents should be able to effectively remove oil. Commonly available chemical agents are organic solvents and surfactants. Since filter cleaning agents need to be dissolved in hot water before cleaning, the organic solvent is inconvenient to be used. The surfactant TS-1withthe role of penetrating and peeling was selected as degreasing agent through experiments. CaCO3and mechanical impurities were removed by a chemical agent, which is compatible well with the media and can convert them into soluble substances or strip them from the filter surface and then remove by water washing. The filter cleaning detergent formulations were determined by a large number of indoorscreening.

(1)The Stripping and fungicidal properties of TS-1 surfactant

TS-1 surfactant can reduce the contact angle of the lipophilic medium surface (see Table 5)and water to change the wettability of oil sands. TS-1 surfactant can also make the direction ofoil sands in the wetting aptitude of hydrophilic to increase the degreasing effect.

Table 5 Dynamic contact angle of carrier film and distilled water

Solution	Advancing angle (°)	Back angle (°)
water	92.98	90.39
Treated water	67.75	60.43

Note: treated with methyl silicone oil slides simulation pro-oily sand

From different angles of scale sheet, multiple SEM imagesenlarged to 250 degree to were shown in Figure 5 and Figure 6, which show the typical results of SEM for pollutant filter prior to immersion (Figure 5) and for contaminated media after 24h immersion (Figure 6).The scanning electron microscopy (SEM) was carried out to describe the effect of the active agent.Compared to the previous immersion, Scale sheet almost peels from the wall after 24h immersion in TS-1 surfactant solution.

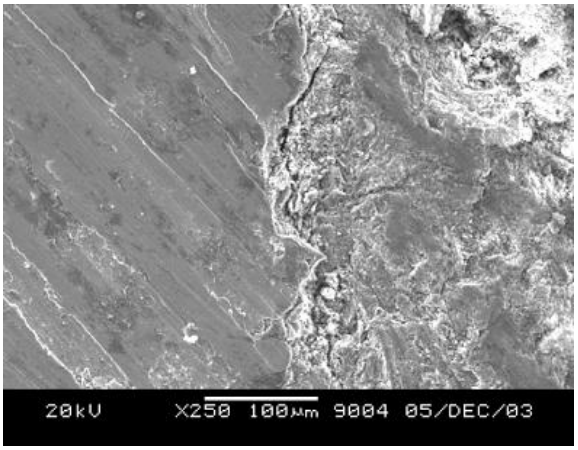


Figure 5 the SEM of unsoaked dirt sheet

Table 6 the determination data of the bactericidal activities of TS-1

C	10000		500		100		50		
	B	S	B	S	B	S	B	S	B
TB	0	100	10^2	99.9	10^3	99	10^4	90	10^5
S	0	100	10^2	99.0	10^2	99	10^4	0	10^4
SRB	0	100	0	100	10^1	99	10^2	90	10^3

TB-Total bacteria, S- Saprophytes, C- concentration (mg/L), B- Bacteria (Number /mL), S-Sterilization rate (%)

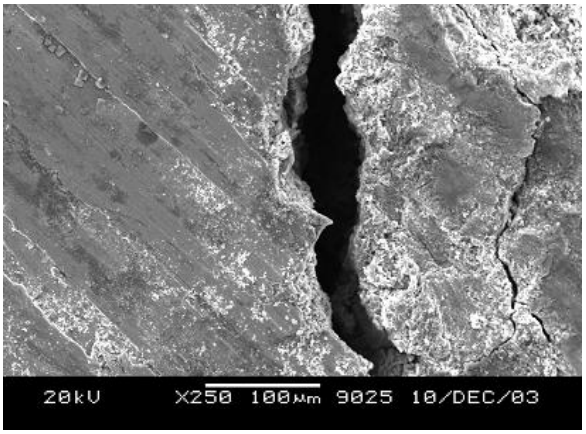


Figure 6 the SEM of soaked scale pieces

When the concentrationof TS-1 reaches to 100mg / L, bactericidal effects on total bacteria, saprophytic bacteria and sulfate-reducing bacteria are up more than 99%.When theconcentration reaches to 10000mg / L, sterilization rate for a variety of bacteria is up 100%. (see Table 6)

（2）The static immersion test of contaminated media (oil sands)

Soaking 5g contaminated media (oil sands) and efficient cleaning agent LD-1,solid-liquid ratio of 1:10; temperature of 45℃, placed after 24h, filtering, drying, weighing calculating wash "oil" rate. The results are shown in Table 7.

Filter cleaning test in oil field

To further evaluate the effect of filter cleaning agent LD-1, filter regeneration tests were taken in sewage stations ofthe third Plant Oil with serious polluted filter.

Table 7 the data of oil displacement from solid interface

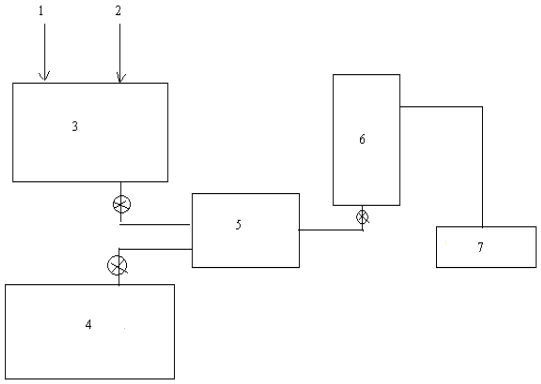
Filter cleaning solution	Concentration (%)	Wash oil rate (%)	The average rate of wash oil (%)
LD-1	0.5	92.9	91.4
		90.8	
		90.5	

Experimental data show that the filter efficient cleaning agent LD-1has a good performance to contaminated media (oil sands), with a wash "oil" rate of 91.4%.

（1）filter cleaning process

The method in Figure 7 is based on the existing processes of sewage stationusing a hot water tank and

a medicament tank . The hot wateris first to be pumped into the filter tank, then medicament. The tank will be soaked for 24 hours and rinsed by hot water. After filter regeneration, waste oil containing other pollutantsis put into the recycled sewage pool for the initial settling and then into a settling tank for processing.



1-50-60℃ water; 2- LD-1; 3- Pharmacy tank; 4-Hot water tank ; 5-Dosing pump; 6- Filter media tank; 7-Waste recycling pool

Fig.7 the rinsing processof oil pollution filtermaterial

（2）Cleaning test results

Filter pollution is very serious before the test and crude oil and suspended solid retention capacity is poor.The filter backwash water can reach the oil content standards using quartz sand filter.Water quality data are shown in Table 8.

Through laboratory tests the parameters of the construction site operation were determined and filter cleaning was performed.The filtrator was monitored after filter cleaning to observe the situation, the data in Table 9.

Experimental data show that the oil content in the water washing is reduced to 0 mg/Lfrom 2.95 mg/L after cleaning the filter media, the solid content of the suspension reduces to 5.8 mg/Lfrom18.25 mg/L before washing,signaling a significant improvement in water quality.

Table 8 the running data of filter before filter material cleaning

time	Oil content（mg/L）		Suspended solids content（mg/L）	
	Filter before	Afterfiltration	Filter before	After filtration
2	4.5	3.1	38.4	19.1
4	3.9	2.9	27.2	17.6
6	3.6	2.6	29.2	18.1
8	4.6	3.2	31.4	18.2
Average	4.15	2.95	31.55	18.25

Table 9 the running data of filter before filter material cleaning

time	Oil content（mg/L）		Suspended solid content（mg/L）	
	Filter before	After filtration	Filter before	After filtration
2	4.5	Trace	38.4	5.3
4	3.9	Trace	27.2	5.6
6	3.6	Trace	29.2	5.7
8	4.6	Trace	31.4	5.9
Average	4.15	Trace	31.55	5.8

Economic benefit analysis

Using quartz sand filter, filter cleaning costs 30,000 yuan. Each filter media replacement cost is calculated by 60,000 yuan. Filter cleaning technology saving rate: (6-3) / 6 × 100% = 50.0%.

There are about 200water treatment stationsin Daqing oilfield and 10 filtersper station, the total number is of 2,000 filters.If estimated by five years of life, there are about 400 media filters be replaced every year, which not only leads to a consumption of a lot of money, but also causes serious environmental hazards. Using filter cleaning technology the cost is 30,000 yuan, thus a comprehensive annual cost savingswill be 12 million yuan, with good economic returns. Taking into account the impact of waste on the environment when replacing filter media, it has good social benefits also.

CONCLUSION

Analysis and discussion of the media's performance in the interception process and

characteristics oilfield wastewater treatment were performed. The static immersion experiments of contaminated media (oil sands) show that wash "oil" rate is 91.4%. Field test data show that the oil content in cleaning water reduce from 2.95 mg / L to 0 mg / L, 18.25 mg / L of suspended solids before cleaning reduced to 5.8 mg / L.The filtration performance of. pollution filter can be restored by choosing appropriate cleaning agents regeneration.

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REFERENCES

Brenna Argall, Sonia Chernova, Manuela Veloso, Brett Browning, 2009 "A survey of robot learning from demonstration", Robotics and autonomous systems, vol.57, pp 469-483.

Guo Ermin, Li Haisheng, Liming, etal. 2005, "Stude on change of traditional filter to continuous sand filter". Research of environmental science，vol.18(5), pp 56-58

Jin ronghuan, Jiao fubin, Chen yuewu, 2011. "Oily pollutin filtering material regeneration technology of oilfield wastewater filtering tanks", environmental protection of oil and gas fields，vol.27(2), pp 3-5.

Sun Tianjin, 2006"The treatment of oilfield wastewater field trials by PTFE membrane filtration device"., Journal of Shengli College China University ofPetroleum，vol.20, pp 7-9

Zhang wen， 2010 "status and progress of oil-bearing wastewater treatment processes in oilfield"., Petroleum Geology and Recovery Efficiency.，vol.17, pp 4108-4110.

Zhen Xianghua, Yu Shuili,Pang Huanyan, 2006, "Treatment of produced water by ultrafiltration for reinjection in the Daqing Oilfield". Environmental Pollution and Control，vol.28(5), pp 329-331