Challenges and strategies of water system in extra high water cut development stage

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Abstract: At present, China's oil fields are in the period of ultra-high water cut production, production capacity continues to decline, the cost of water resources continues to rise, the input and operating costs of water supply system continue to increase, it is very difficult to reduce costs, improve benefits; With the change of chemical flooding to thin and poor formation, the exploitation and utilization of heavy oil in Fuyu Oilfield and its surrounding area require higher water quality. At present, it is urgent to solve the fine treatment of mining water and the recovery technology of fracturing wastewater. Due to the aging of the station, there are numerous safety and environmental issues, so the work of reducing energy consumption is onerous. Faced with many new problems, the water industry must plan ahead, control investment, reduce costs, maintain water quality, improve efficiency, and develop and reserve suitable technologies.

Key words: Extra high water cut development stage; Water system; Oilfield water system

1. Introduction

"Difference", and more long-term development stage, to give full play to the existing water supply facilities of waste heat, and water supply of new sites to strict management, through the development of chemical flooding station, reduces the treatment station displacement ability, reduce the displacement capacity of treatment station, reduce the amount of sewage processing, improved the success rate of sewage, with large flow plunger pump, It can significantly reduce energy consumption per well. At present, China's petroleum industry is actively promoting digitalization, through intelligent water injection, intelligent water, digital drainage, water treatment technology level continues to improve.

2. Super high water cut development stage

During the 12th Five-Year Plan period and the 13th Five-year Plan period, according to the general requirements of "good water injection, enough water injection, fine water injection and effective water injection", daqing Oilfield vigorously promoted the "high-quality development" and "green mine". It increased the investment of technology and funds in water system, developed new technology and strengthened the production and operation of enterprises. So that the water system to meet the standard rate and the utilization rate of the system has been significantly improved. Standardized, modular and skid-equipped construction methods are of great significance to speed up the laying of pipe network and shorten the construction period. Through the optimization and simplification of water treatment, ultra-low permeability water treatment technology, crack filtration technology, new water injection technology and the promotion of new water injection technology, has made a significant contribution to water treatment technology to improve quality and efficiency, saving construction investment. The research and development of electric flotation technology, air flotation technology and microbial treatment technology has laid a solid foundation for the development of water supply technology during the 14th Five-year Plan period. Daqing Oilfield is in the period of high water-cut production and is faced with many new problems. How to control investment, reduce costs, improve water quality and improve benefits, it is necessary to plan ahead, develop and reserve applicable technologies to promote high-quality and sustainable development of oil and gas business [1].

3. Challenges of water system in the stage of ultra-high water cut development

3.1 It is difficult to reduce cost and increase efficiency

The development index forecast targets of "14th Five" oilfield are shown in Figure 1 below. With the increase of water content, water consumption shows an increasing trend, the number of new stations keeps increasing, and the proportion of water supply system in production capacity and renovation projects gradually increases. The investment of comprehensive flooding system takes up about 50% of the investment in surface engineering, excluding oil recovery engineering, which is included in the surface investment. Therefore, the pressure of optimization, simplification, cost reduction and efficiency increase will gradually increase.

Table 1 Development index forecast in the 14th Five-year Plan

year	Oil production (104t·a-1)	Produced fluid volume (104t·a-1)	Water injection (104t·a-1)	Water rate (104t·a-1)	Filling water (104t·a-1)	Comprehensive water cut%
2021	2900	60539.2	73038.3	57639.2	15399.1	95.21
2022	2800	61410.5	74142.2	58610.5	15531.7	95.44
2023	2700	62539.0	75567.3	59839.0	15728.3	95.68
2024	2600	63915.6	77266.3	61315.6	15950.7	95.93
2025	2500	65806.6	79505.0	63306.6	16198.4	96.20

3.2 The technology needs to be tackled

With the development of non-traditional reservoirs, the fine treatment of mined water and recovery of fracturing flowback fluid are urgently needed. In the development and utilization of peripheral heavy oil and peripheral ultra-low permeability oil, the produced sewage is increasing day by day, and the oil content is ≥5mg/L, suspended solid content is ≥1mg/L and particle size is <1 micron, which meet the requirements of ultra-low permeability oil field water injection. Therefore, the economic and feasible fine treatment technology of produced water needs to be further solved. With the exploitation of non-traditional oil and gas reservoirs, the number of large-scale fracturing is increasing every year, and the requirements for fracturing are becoming higher and higher. Meanwhile, the number of fracturing flowback fluids and other waste water is also increasing sharply, which has a greater impact on sewage treatment stations and sites, thus restricting the improvement of water quality compliance rate. Water scarcity will limit the development of non-oil and gas reservoirs, strengthen the protection of water resources, and gradually eliminate industrial groundwater extraction [2].

3.3 The task of saving energy and reducing consumption is arduous

Because of the large number of stations, there are some safety and environmental problems, and the work of energy conservation is very heavy. The number of aging stations is relatively large, and there are many old stations, high security risks, and a large amount of maintenance and transformation tasks. With the increasingly strict environmental protection and environmental protection laws in China, the reconstruction of railway stations will have great difficulties. The energy consumption per unit of water injection in China's oil fields is high, especially the energy consumption per unit of water injection. The average water injection consumption per unit of water injection is 5.93kWh/m3. Based on the calculation of the water injection volume of 7x108m2 in 2019, the annual power consumption of water injection in oil fields is 41.51×108kWh, and the energy saving space is large.

4. Technical strategy of water system in extra high water cut development stage

4.1 Make full use of the remaining capacity of existing facilities

The water injection system and produced water system have some surplus capacity at present, which should be rationally developed to reduce engineering investment. At the same time, give full play to the advantages of the good connection of existing pipelines and the exploitation time of chemical flooding, add connecting pipelines reasonably, tap the potential of chemical flooding station, and strengthen the balanced operation within the station. The workload of the water supply equipment is shown in Table 2 below. Realize the connection of raw water and treated water between water flooding, polymer flooding and ternary flooding treatment stations, give full play to the potential of effluent treatment, reduce new investment, and reduce the content of raw water polymers and other oil flooding agents in sewage, thus reducing the difficulty of treatment and improving the standard rate of sewage. The connection between water injection well and chemical flooding water injection pipeline is realized, the workload of water injection plant is increased, and the water injection work scheme of water injection plant is optimized, so that the single consumption of water injection device is improved obviously.

Table 2 Water system operating load

The name of the system	The system category	Ability to design / ($10^4m^3 \cdot d^{-1}$)	Running water / ($10^4m^3 \cdot d^{-1}$)	Operation load / %
Water injection system	Changyuan water drive	149.1	90.4	60.6
	Placanticline chemical flooding	82.2	63.9	77.8
	Periphery and sea tower	53.6	33.5	62.6
	A combined	284.9	187.8	66.0
	Water drive	145.5	106.3	73.1
Produced water treatment system	Polymer flooding	94.1	65.4	69.5
	Asp flooding	16.1	10.2	63.3
	Depth of processing	142.3	85.5	60.1
	Periphery and sea tower	9.2	7.6	82.5
	A combined	407.2	275	67.5

4.2 Optimize construction scale

With the industrialization of polymer flooding, the treatment technology of wastewater treatment station cannot meet the requirements because the produced water treatment station of water flooding is connected with polymer. The work load of water treatment station and deep treatment station is more than 80%, and the corresponding design is carried out according to the requirements of water flooding. In the waterflooding process, when the polymer concentration is less than 150mg/L, the waterflooding process is optimized according to the waterflooding process conditions. There is no special limit on the amount of polymer material in deep treatment plant, and its design indexes are carried out according to the requirements of water flooding. The regulation has been in place for more than 20 years, and the construction scale of various sewage plants is calculated based on 80% of operating load. It is proposed that under the condition that the oil production treatment station, asp flooding produced water treatment station and peripheral produced water treatment station are not retained in accordance with 20% capacity, such stations can save about 15% of construction investment [3]. For industrial sewage such as fracturing flowback fluid, water injection pipeline flushing water, well washing water, etc., it should be limited to the maximum daily water flow, average daily water flow or water yield after peak clipping by cache. The greater the difference in value, the greater the influence on the construction scale of treatment station.

4.3 Popularize and apply new filter tank

In oilfield sewage treatment, filter tank is an important equipment, the quality of its treatment will have a direct impact on the quality of sewage and water injection exploitation. The new filter structure is shown in attached figure 1. In order to overcome the problems in the existing filtration equipment in the oilfield, a kind of filter tank can effectively solve the problems encountered in the actual operation of the oilfield, with high treatment efficiency and 40% less investment is developed, which is worth popularizing and using vigorously. The advantages of the invention are: the mixing cylinder is removed, so that the structure of the filter cylinder can reach the function of broken plate, saving the cost of the device and the operating cost; The scheme effectively overcomes the problems of filter tank pressure and filter material regeneration, and effectively reduces the loss of filter material. The interior of the filter tank is optimized to eliminate dirt in the cleaning process; Without rotating parts, operation is easier and automation is easy to achieve. Oilfield companies can also achieve self-production and improve their economic efficiency.

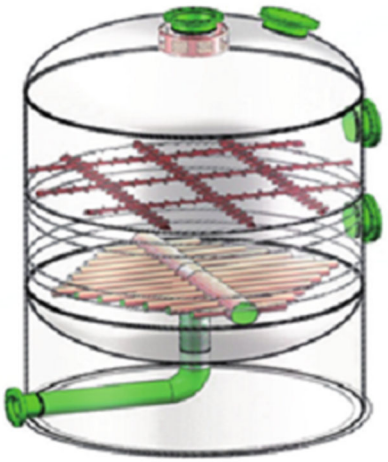

Fig. 1 New filter tank structure

4.4 Fine treatment technology of produced water is preferred

Hollow fiber ultrafiltration membrane technology has been widely used in municipal water supply treatment and other industries. It has the advantages of low cost and long chemical cleaning cycle, but it has poor resistance to oil and other pollutants, and requires a long pretreatment time. Ceramic ultrafiltration membrane has good anti-fouling performance, high working pressure, high water capacity and long service life, but the membrane cost is high, the chemical cleaning cycle is short, the operation of energy consumption. Because the pretreatment technology and membrane type of the treatment station are not consistent, it needs to be further summarized and optimized to provide reference for similar engineering construction.

4.5 Increase the application of efficient water injection pump

The water injection pump consumes a lot of energy. At present, various oil fields are committed to improving the energy saving effect of the water injection pump, including frequency conversion speed regulation, hydraulic coupler speed regulation, pre-pump frequency conversion speed regulation, pump structure transformation, etc. Due to the limitation of its structure, its working efficiency of about 78% has been close to its maximum value. In GB/T9234-2018 national standard "Motorized Reciprocating Pump", when the rated discharge pressure of the plunger pump is less than 20MPa, its pump efficiency is greater than 87%, and under the discharge pressure of 20~ 31.5mpa, its efficiency is more than 86%, which is 10% higher than the efficiency of the centrifugal injection pump unit. With the expansion of production scale in China, a number of large flow piston pumps have been developed, which provides a good foundation for saving energy by water injection in oilfield. In Shengli oilfield and Zhongyuan oilfield, more than 30 sets of high-flow plunger pumps were used instead of centrifugal pumps to pump water, and obvious energy saving benefits were obtained. It can be seen that the use of high-flow plunger pumps can significantly reduce the single well water injection.

4.6 Fracturing flowback fluid recycling

The comprehensive waste liquid of oil field mainly includes fracturing flowback fluid, well washing wastewater, water injection line flushing water and so on. The existing treatment process is to build a wastewater collection tank, use tank trucks or temporary pipelines for recovery, after buffering and then sent to the adjacent sewage treatment plant or gathering device, after treatment and then integrated recovery with the water production of the formation. The composition of fracturing flowback fluid is complex, and it is more difficult to treat than the three-element effluent. It also causes great pollution to the produced water treatment station and has a great impact on the water quality of the produced water treatment station. The fracturing flowback fluid should be treated with compound treatment to minimize the production of wastewater, minimize the impact on the surface and reduce the pressure of water injection.

5. Conclusion

In the face of complex development environment, water system is faced with great challenges and opportunities. It will not only improve the quality and promote the development of the main industry, but also promote the continuous improvement of the technical level of oilfield water system in China. In order to achieve intelligent water injection as soon as possible and greatly reduce the single consumption of water injection, the water injection system should seize the favorable opportunity of digital transformation of current oilfield, improve the operation level of oilfield enterprises and strengthen the use of effective energy-saving equipment by optimizing the operation of the system.

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