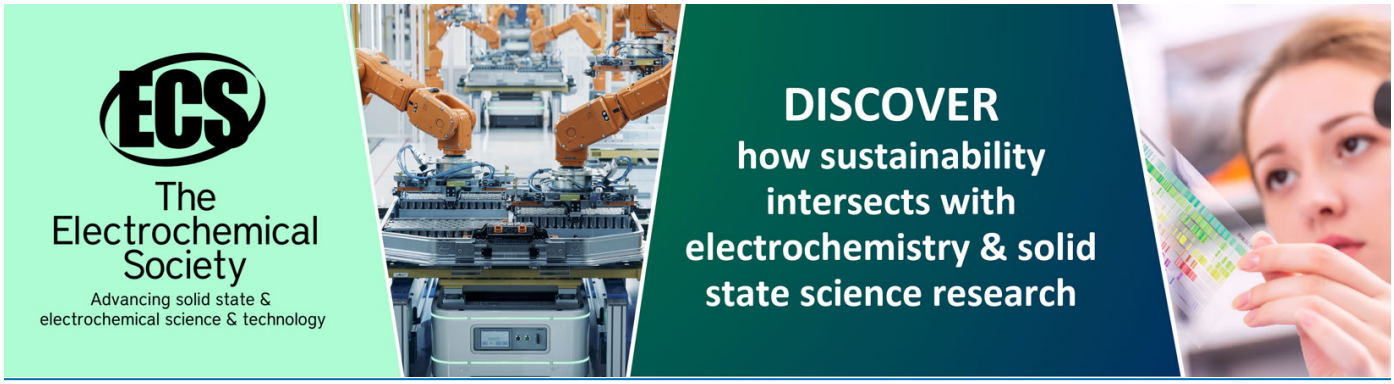
Integrated Separate Layer Injection Technology on Water-Polymer Full Term Flooding for II and III Kind Formation



Integrated Separate Layer Injection Technology on Water-Polymer Full Term Flooding for II and III Kind Formation

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Abstract: With the development of polymer flooding in Daqing oilfield, the II and III formation with low permeability and apparent interlamination contradictory has been developed for the main target. Due to the big difficulty of testing, the low successful ratio of running and fishing, the high cost of changing the strings for water flooding and polymer flooding, the original separate layer polymer injection failed to be applicated extensively. In order to resolve the problems mentioned above, the integrated separate layer injection technology on polymer flooding was researched in this paper. The eccentric injection regulator, the pressure regulator with low viscosity loss ratio and high pressure choke, the molecular weight regulator with high viscosity loss ratio and low pressure loss are designed, the injetion of high permeable interval and the molecular weight of medium and low permeable interval can be controlled at the same time. The separate injection string is compatible with water flooding technology and it can be satisfied the requirement of the blank water flooding, polymer flooding and sequent water flooding, the investment and operation cost are dropped. The field application of more than 1000injection wells show that the empoly degree of the II and III kind formation is improved obviously and the rude oil revovery enhanced 2 percent above after using the new style separated injection technology.

1. Introduction

The Daqing oilfield practice shows that polymer flooding compared with water flooding can be more increased the oil recovery over 20 percent [1, 2]. At present, Daqing Oilfield totally have 728 ternary production wells and 625 injection wells, the oil production maintain keeps more than one million tons for three consecutive years and the cumulative oil production is 6.135 million tons. With the deepening of the development of polymer flooding, permeability differences, second and third grade reservoirs with much interlayer difference has become the main development of the object. Original polymer flooding separated injection technology, has poor process adaptability, the water flooding turning into polymer flooding and polymer flooding turning into subsequent water flooding due to high cost, it needs to replace the string and unable to scale application.

In order to solve the above problems, this paper researches the integrated separate layer injection technology on water-polymer full term flooding technology, to achieve the dual control of the Injection volume of the high permeability interval and the molecular weight of the low permeability interval, researches the pressure regulator with low viscosity loss ratio and high pressure choke, the molecular weight regulator with high viscosity loss ratio and low pressure loss. The separate injection string is compatible with water flooding technology and it can satisfy the requirement of the blank

water flooding, polymer flooding and sequent water flooding, the investment and operation cost are dropped. Integrated separate layer injection technology has the scale application conditions, and plays an important effect on continued stable and high yield for Daqing Oilfield 40 million tons crude oil.

2. Integration eccentric regulator

The integration eccentric regulator adopt eccentric structural design, tools outer diameter is 114mm, length is 1640mm, center channel diameter is 46mm, the partial hole inner diameter is 20mm.

The injection allocation plugging into partial hole to achieve separate injection allocation (Figure 1). Compared with the original process, the pulling load drops to 50%, one-time pulling success rate grows from 85% to 95.6%.

The injection regulator with water flooding process is fully compatible and can be used directly in water flooding pulg and separate layer testing and commissioning process to achieve layered water injection, and is compatible with the recent development of efficient testing and commissioning process. This kind of injection regulator can cut down the cost of replacement string caused by different injection liquid.

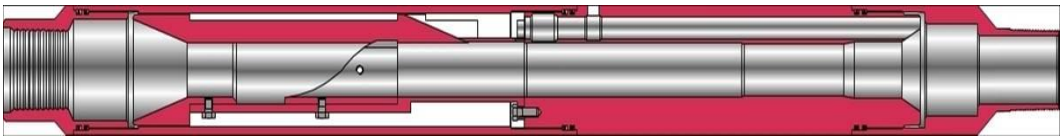

Fig. 1 integration eccentric regulator schematic diagram

3. Low viscosity loss throttling pressure regulator

3.1 Streamlined annular antihypertensive groove structure throttle core

Due to the shear degradation rate of polymer molecular weight in polymer solution has a direct relationship with the flow velocity and flow field [3, 4], in order to reduce the shear degradation of the polymer molecular weight, optimizing the streamlined annular antihypertensive groove structure throttle become the core design. Throttle core outer surface has a number of levels equidistant streamline unit, with eccentric mandrel partial pore inner walls formed flow channel. When polymer solution flow through each throttle unit, the flow area changes from small to big once, the flow rate changes from high to low once the flow pattern and flow distribution consequential changes. Thus, the polymer molecular is always in elongated, shrinkage during the deformation. That part of energy consumed in deformation and recovery of the polymer chain, thereby forming a local energy loss, resulting loss of pressure, form throttle pressure difference. Application of computational fluid dynamics software on the flow field analysis of semicircle and streamlined antihypertensive unit (Fig. 2, Fig. 3).

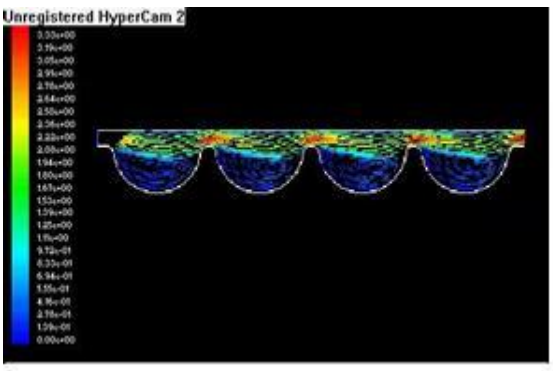

Fig. 2 semicircle antihypertensive unit

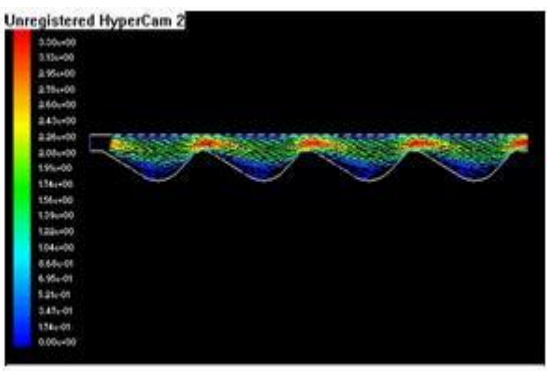

Fig. 3 streamlined antihypertensive unit

The calculation results show that: the streamlined antihypertensive unit pressure distribution more uniformity than the semi-circular antihypertensive unit, flow field tend to be stable, flow around phenomenon significantly lower than that of the latter, should not occur turbulence; semi-circular antihypertensive unit due to flow around, reflow phenomenon is more serious. Therefore, we preferred streamlined throttling core of the multi-stage antihypertensive unit. Throttle core outer diameter is 18mm, smaller size, lower pulling loads; design elements of combined structures used in tandem for reducing the investment cost.

3.2 Pressure regulate plug

Pressure regulate plug and integration eccentric regulator supporting the composition of pressure regulator (Figure 4). To control injection pressure of injection interval by pulling change streamlined annular antihypertensive groove of different slot number [5, 6].

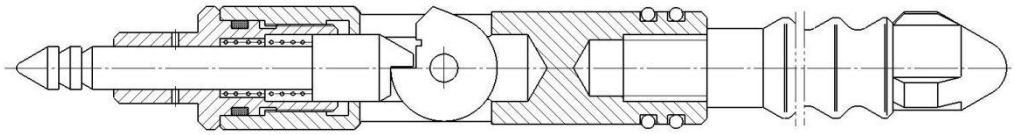

Fig. 4 pressure regulate plug schematic diagram

Performance index：

Pressure regulate plug in the flow range of 50m^3/d, maximum throttle pressure difference of 1.2MPa, and viscosity loss rate of 8.2% (Figure 5).

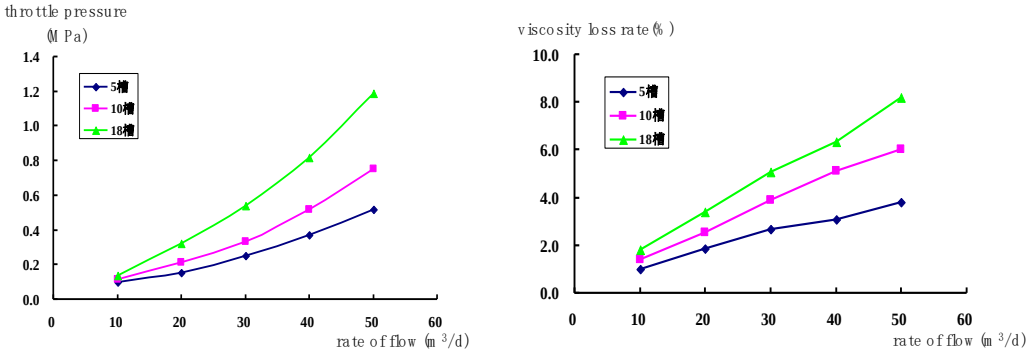

Fig. 5The flow rate-throttle pressure difference-viscosity loss rate of pressure regulate plug

4. The high viscosity loss low pressure loss molecular weight regulator

4.1 Polymer molecular weight regulation mechanism

The rheological property of aqueous polymer solution is non-Newtonian fluid has both viscous and elastic nature. The polymer molecules microscopic particles, dendritic structure and reticular distribution in aqueous solution, the structure of the molecular chain are a flexible chain. Pressures on the external, the molecular conformation can be changed, can stretch that curled the polymer chain, when the tensile force is removed, but also to restore its natural twist shape. When the polymer solution sharp variation due to the speed, the shear stress exceeds the critical resolved shear stress on the polymer molecular chain, the molecular chain is broken, resulting in irreversible inversion recovery, to achieve the purpose of mechanical degradation. It can lead to decomposition and fractured of a molecular chain, morphology and size of the polymer molecules changes, resulting in the decrease of the molecular weight of the polymer[7](Figure 6).

4.2 Molecular weight regulatory elements

According to the above-mentioned mechanical degradation principle, designed the "hyperbolic curve + trapezoidal mouth" type nozzle molecular weight regulatory elements (Figure 7). By changing the nozzle diameter, degradation strength of the polymer can be controlled, in order to adjust the molecular weight of the polymer (nozzle made of ceramic material, D1 Φ2.0-6.0mm, 0.2mm as intervals increasing).

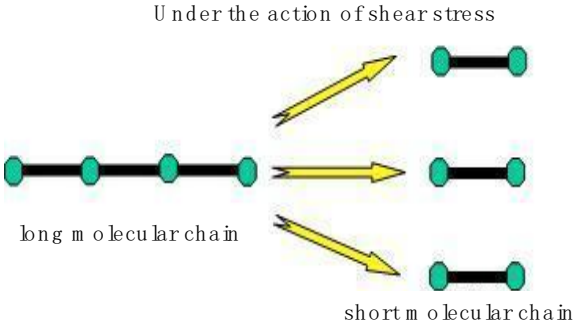

Fig. 6 the sketch of shearing of polymer molecular weight

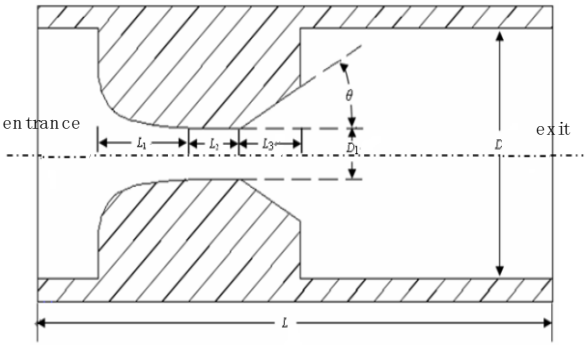

Fig. 7 "hyperbolic curve + trapezoidal mouth" type nozzle molecular weight regulatory elements

4.3 Molecular weight regulate plug

Molecular weight regulate plug and the integration eccentric regulator, form a complete set of the molecular weight regulation technology (Figure 8).Replacing the nozzle diameter to control the molecular degradation rate, it can reach to the purpose of adjusting the polymer molecular weight in polymer solution.

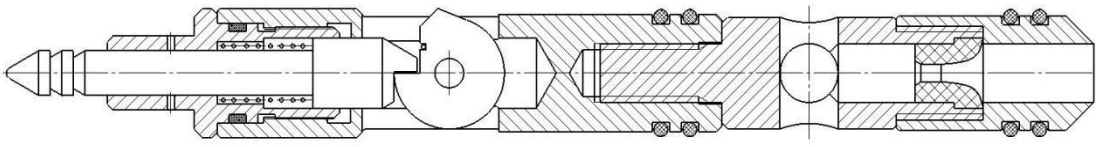

Fig. 8 Molecular weight regulate plug schematic diagram

Achieved performance indexes：

Molecular weight regulator in the flowing range of 50m^3/d, the maximum molecular weight regulator adjustment range can reach 50%[8]（Figure 9）.

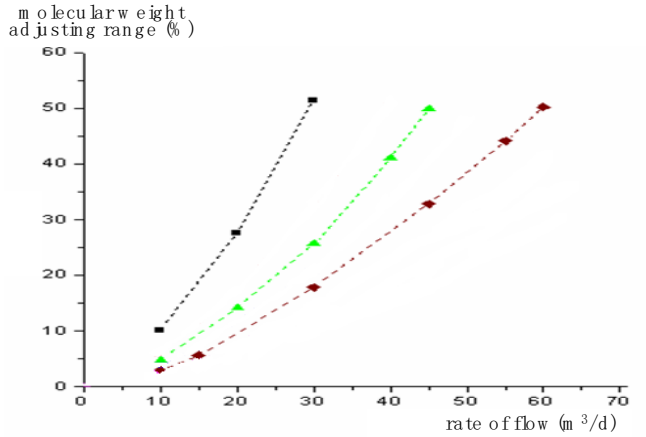

Fig.9 molecular weight adjusting range curve of molecular weight regulator

5. Field Applications

Up to now, the integrated separate layer injection technology on water-polymer full term flooding technology has been applied in more than 1000 Wells in daqing oilfield. The technology is fully compatible with the high-efficiency test and adjustment process of water flooding, and meets the requirements of water flooding, polymer flooding and subsequent water flooding in different stages as well as high concentration polymer injection. This technology has a simple test process, and the fishing load is similar to that of ordinary water flooding well test. The test team can independently complete the fishing, sealing inspection and test deployment.

According to the statistics of 15 injection-24 production in the west block of north 1-2 plateform, after separate injection, the operating layers are 9.8 percentage points higher than general Wells, and the operating thickness is 10.3 percentage points higher. The sealing rate of the whole well was 100.0%, the qualified rate of polymer injection was 87.7%, and the success rate of primary fishing was 95.6%. After applying the separate injection technique, the suction thickness of the polymer injector is obviously increased, and the production condition of poor reservoir is obviously improved.

6. Conclusions

(1) The integration dispensing string of polymer flooding with water flooding process is fully compatible.String can meet blank water flooding, the polymer flooding and subsequent water flooding the whole process of the dispensing needs, reduce the investment and construction cost.

(2) The pressure regulator with streamlined annular hypotensive groove structure, when the flow rate is 50m^3/d,the maximum throttle pressure difference can reach 1.2MPa, the viscosity loss rate is 8.2%.

(3) The molecular weight regulator "hyperbolic curve + trapezoidal mouth" structure, when the flow rate is 50m^3/d, the maximum molecular weight adjustment range can reach 50%.

(4) Field tests in more than 1000 Wells show that the new injection separation process can significantly improve the production performance of the II and III class reservoirs and increase the oil recovery by more than 2 percentage points.

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