Study on Optimization of Injection Parameters for Binary Compound Drive System

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Abstract. In this paper, numerical simulation technology was used to optimize the injection of polymer/surfactant binary flooding system. The results of the study show that: (1) Under the conditions of reservoir physical properties studied, the polymer surfactant binary complex system has improved oil recovery by 18.9%, 5.6%, and 7.3, respectively, over water flooding, polymer flooding, and surface active flooding. (2) The results of the study show that the later the binary flooding time is, the lower the recovery factor is, but the overall impact is smaller; (3) When the pre-slug volume is 0.05 PV, the binary flooding development effect is optimal; (4) The concentration of polymer and surfactant was calculated and analyzed. Under the reservoir physical properties studied, the polymer concentration was 1500 mg/L and the surfactant concentration was 0.3%.

Keywords: Binary Compound Drive System; Polymer; Surfactant; Concentration.

1. Introduction
At present, the development of old domestic oilfields has become more difficult and the mining costs have increased. The polymer flooding in some blocks has ended and the water content has reached 98%. How to carry out subsequent high-efficiency development has become an urgent problem to be solved. Binary composite flooding has great potential for development due to its common characteristics of polymers and surfactants. This study has optimized the injection parameters of the binary system, optimized the parameters such as the size of the pre-slug of the binary flooding, and provided...
suggestions for the determination of the injection parameters of the binary water flooding for the high-water-cut oilfield.

2. The establishment of numerical simulation model
Based on CMG software, a single-layer plane homogenization model (permeability 500md) and five-layer heterogeneity model (100, 200, 500, 800, and 1000 md) were established, and binary injection parameters of different models were optimized. The well network uses a five-point area well pattern with a well spacing of 150m.

3. Injection parameter optimization

3.1. Injection reagent selection
Under the premise of equal economic indicators, the water recovery, individual polymer flooding, surface active flooding, and binary flooding recovery were respectively calculated. The calculation results show that for a single-layer homogenization model, the binary recovery system achieves 15.3%, 3.2%, and 5.1% higher recovery than water flooding, polymer flooding, and surface-active flooding, respectively; for multilayered heterogeneous models, compared with water flooding, polymer flooding, and surface-active flooding, the polymer surfactant binary complex system achieved enhanced oil recovery of 18.9%, 5.6%, and 7.3%, respectively. For plane homogeneous reservoirs, binary flooding results in a higher extent of enhanced oil recovery for inter-layer heterogeneity reservoirs. This is due to the fact that the plane is a homogenous reservoir, the water flooding recovery is high, and the volume expansion of binary flooding is large. The effect is not significant; while for inter-layer heterogeneous
reservoirs, the surfactant can increase the oil washing efficiency of the reservoir, and at the same time, the medium and low permeability reservoirs can be better utilized due to the polymer sealing effect. Recovery is increased.

![Fig.4 The recovery curve of different injection substances](image)

3.2. Binary injection timing
The timing of binary flooding was analyzed. Water flooding to different levels (70%, 80%, 85%, 90%, and 95%) is converted to binary flooding, and the recovery factor is calculated for different binary injection timings. The results of the study indicate that the later the flooding time, the lower the recovery factor, but the smaller the overall impact.

![Fig.5 Recovery rate curve with injection timing](image)

3.3. Pre-segment volume preference
The pre-slug volume was simulated. Waterflood water content was 70%, and it was converted to binary flooding. The total amount of binary water was constant, and the pre-slug volume was (0.01, 0.02, 0.05, 0.10, and 0.15) PV. The purpose of injection into the pre-slug is to block the dominant percolation channel. When the volume is too small, the plugging effect cannot be achieved; but when the volume is too large, the volume of the bi-component main plug is exceeded when the volume is too large. Small, not a good oil displacement effect, so the pre-slug there is an optimal value, the calculation results show that the current development of the slug volume is 0.05PV when the development of the best results.
3.4. Main slug volume and injection concentration are preferred

A preferred study was performed on the injection volume and the injection concentration of the binary drive slug. The purpose of injecting the binary main slug is to increase the sweep volume and oil washing efficiency, so the polymer concentration is moderate to expand the sweep volume, and the surfactant concentration should reduce the interfacial tension to the order of \(10^{-2}\) to \(10^{-3}\). In other economic situations, the calculation results show that the optimal combination is an experimental protocol with a polymer concentration of 1500 mg/L + surface active agent concentration of 0.3%.

| Experimental program | Binary concentration |
|----------------------|----------------------|
| 1                    | 1000mg/L+0.1%        |
| 2                    | 1500mg/L+0.1%        |
| 3                    | 2000mg/L+0.1%        |
| 4                    | 1000mg/L+0.2%        |
| 5                    | 1500mg/L+0.2%        |
| 6                    | 2000mg/L+0.2%        |
| 7                    | 1000mg/L+0.3%        |
| 8                    | 1500mg/L+0.3%        |
| 9                    | 2000mg/L+0.3%        |

4. Conclusion

(1) Under the reservoir physical properties studied, the polymer surfactant binary complex system has higher recovery ratios of 18.9%, 5.6%, and 7.3%, respectively, than water flooding, polymer flooding, and surface-active flooding.

(2) The results of the study show that the later the binary flooding time, the lower the recovery factor, but the overall impact is smaller.
(3) When the pre-slug volume is 0.05PV, the binary flooding has the best development effect;
(4) Orthogonal design optimization study was conducted on the concentrations of polymer and surfactant. Under the reservoir physical properties studied, the polymer concentration was 1500 mg/L and the surfactant concentration was 0.3%.

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