Recovery Characteristics of Weak Alkali ASP Flooding in Second Oil Reservoir

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Abstract. Taking two weak alkali ASP flooding test blocks as the research object, the injection-production characteristics, effective characteristics, agent recovery characteristics, reservoir inhalation condition, pressure characteristics and emulsification characteristics were analyzed. The results showed that the weak alkali ASP flooding had strong injection-production ability, high oil recovery rate, improved suction condition, established effective driving pressure system, obvious emulsification, and not serious chromatographic separation. The apparent inhalation index decreased by 23%-33%, and the liquid production index decreased by 31-42%; The inhalation thickness ratio were 89.5%-92.7%, and the water cut decreased by 16%-20%; The enhanced recovery increased by over 20% in the weak alkali ASP flooding of the second oil reservoir.

1. Introduction
Field test showed that compared with water flooding, extraction time was short, phased and dynamic change fast in ASP flooding [1-2]. In order to guarantee the development effect, based on the end of SD1 and SD2 blocks, the change rule of key development indicators were analyzed, and dynamic change characteristics of different injecting stage were understanded in weak alkali ASP flooding. The technical suppor of optimization design in the process of development and timely tracking were provided.

2. Comparison of geological conditions in different ASP flooding blocks
The SD1 block and the SD2 block belonged to the middle stream system and the large lasi river system. Affected by different sedimentary systems, the development of the second oil layer in the east of pure oil was significantly worse than that in the western part, which was characterized by more oil layers, thinner single layer thickness, poor permeability, strong heterogeneity and poor continuity of sand body. The comparison between the development of reservoirs in SD2 block and SD1 block showed that the thickness of single layer, permeability, the proportion of connectivity thickness and the controlling degree of polymer flooding in SD1 block were 1.7m, 0.146μm², 40.6% and 19.1% lower than that in SD2 block, respectively.

Table 1. Comparison table of basic situation in different ASP flooding block

| Block | Well spacing (m) | Sand thickness (m) | Effective thickness (m) | Permeability (μm²) | Controlling degree of polymer Flooding (%) |
|-------|------------------|--------------------|------------------------|-------------------|------------------------------------------|
| SD1   | 125              | 9.4                | 7.1                    | 0.387             | 71.1                                     |
3. Recovery characteristics

3.1. Injection characteristics

The comparison of injection pressure change and apparent inhalation index between SD1 block and SD2 block showed that the injection pressure increased rapidly and the injection capacity decreased obviously in the pre-polymer slug stage, and then the injection pressure increased slowly and the injection capacity decreased slowly synchronously. The injection pressure rose to the highest (10.2MPa-12.7MPa) at 0.35PV-0.45PV, after which the injection pressure and apparent inhalation index basically remained stable. The injection pressure in two blocks increased at a rate of 1.11-1.21MPa/0.1PV, with a maximum increase of 61.6% to 71.5%. The apparent inhalation index decreased by 23.1% to 33.3%. The weak alkali ASP flooding had a strong injection capability, and the better the geological condition was, the lower the initial injection pressure was, the larger the rise range was, the stronger the injection capability was[3].

| Block                        | Increase of injection pressure (%) | Rate of increase of injection pressure (MPa/0.1PV) | Injection speed (PV/a) | Decrease of apparent inhalation index (%) |
|------------------------------|----------------------------------|-----------------------------------------------|------------------------|-----------------------------------------|
| Different ASP blocks         | 60-80                            | 1.0-1.2                                       | 0.18-0.28              | 25-35                                    |
| Similar geological conditions block | 70-80                            | 1.0-1.2                                       | 0.18-0.28              | 25-30                                    |

3.2. Production characteristics

The comparison of water cut and liquid production index between SD1 block and SD2 block showed that water cut fell to the lowest point 79.7%-80.8% and the largest drop in liquid production index was 31.3%-42.6% when ASP chemical was injected at 0.3PV. After that, the liquid production capacity did not change much. The low water cut stability time was 0.42PV-0.43PV. The water cut started to rise, and the rise rate was slowly 1.5%/0.1PV-1.6%/0.1PV after ASP chemical was injected at 0.7PV. The weak alkali ASP flooding in the second reservoir had a strong liquid recovery ability, and the better reservoir conditions were beneficial to maintain the high liquid recovery ability[4].

| Block                        | Lowest water cut (%) | Water cut the most (%) | Low water stability time (PV) | Water recovery rate (%/0.1PV) | Decrease of production index decline (%) |
|------------------------------|----------------------|------------------------|------------------------------|-----------------------------|------------------------------------------|
| Different ASP blocks         | 80 Or so             | 16 above               | 0.40 above                   | 1.5-2.2                     | 30-45                                    |
| Similar geological conditions block | Less than 80          | 20 Or so               | 0.40 above                   | 1.5-2.2                     | 30-35                                    |

3.3. Effective characteristics

The response wells ratio of SD1 block and SD2 block were 100%. The water cut decreased more than 20% in 65% or more production wells. With the decrease of water cut, the rate of oil recovery increased rapidly after ASP chemical was injected at 0.1PV. The water cut decreased to the lowest and the oil recovery rate was 10.5% to 11.8% when ASP chemical was injected at 0.3PV. After the peak period, the oil recovery rate decreased slowly with the decrease of water cut. The enhanced recovery in the two blocks increased by over 20%.

3.4. Agent recovery characteristics
The comparison of chemical agent produced in SD2 block and SD1 block showed that the polymer, alkali and surfactant appeared at 0.064PV and 0.074PV, 0.192PV and 0.11PV, 0.221PV and 0.225PV, respectively. In SD2 block and SD1 block, the relative polymer concentration increased steadily to 0.64PV and 0.75PV, respectively, reaching peak values of 0.71 and 0.6. The relative concentration of alkali picking and surfactant slowly rose to about 0.45PV, and the rising speed was accelerated, reaching the highest value at about 0.6PV, in which the highest relative concentration of alkali picking was 0.16 and 0.27, respectively, and the highest relative concentration of surfactant was 0.13 and 0.2, respectively. The highest concentration of polymer, the lowest of surfactant and the middle concentration of alkali were observed in the peak period.

| Table 4 Production time and peak relative production of chemical agent in different ASP block |
|-----------------------------------------------|------------------|------------------|------------------|
| Block | The pore volume multiples of the chemical were injected at the time of chemical agent production (PV) | The relative recovery of chemical agent at peak time |
|-------|-------------------------------------------------|-------------------------------------------------|
|       | Polymer | Alkali | Surfactant | Polymer | Alkali | Surfactant |
| SD1   | 0.074   | 0.110  | 0.225      | 0.60    | 0.27   | 0.20       |
| SD2   | 0.064   | 0.192  | 0.221      | 0.71    | 0.16   | 0.13       |

3.5. Pressure characteristics
The comparison between injection and production pressure difference in SD2 block and SD1 block showed that the production pressure difference in the two blocks gradually increased from 8.02MPa and 13.53MPa in blank water flooding to 13.97MPa and 17.81MPa in water-cut recovery stage, respectively, indicating that the flow resistance increased continuously after injection of chemical agents and the reservoir was effectively utilized.

3.6. Inhalation condition
As chemical injection, injection pressure of SD1 and SD2 blocks rising steadily, interwell pressure tended to equilibrium, inhalation condition improved, inhalation thickness ratio up to 89.5% - 92.7%, increased by 7.2% - 11.5% before the chemical injection. The proportion of producing thickness in thin oil reservoir after ASP flooding was increased by 10.6% to 18.4%.

3.7. Emulsification characteristics
The results showed that the strong emulsification ability of the reservoir with high permeability and strong heterogeneity could improve the oil displacement effect. Weak alkali ASP flooding had a strong emulsification ability, with the proportion of emulsified wells up to 84.4% to 86.4%, among which the proportion of severely emulsified wells was 27.1% to 50%. The water cut of emulsified wells decreased greatly, and the oil displacement effect was good. Compared with the unemulsified wells, the water cut of the emulsified wells decreased by 15% to 25%. From the emulsion type, the well with severe emulsification was oil-in-water type, and the light well was oil-in-water and oil-in-oil type. The viscosity of the produced emulsion was up to 86.9 mPa.s-96.3 mPa.s, which could effectively adjust the oil-water flow ratio, expand the affected volume and improve oil displacement efficiency.

4. Conclusion
Weak alkali ASP flooding had strong injection-production ability, significant oil-precipitation effect, and obvious improvement in utilization status. It could establish an effective driving pressure system with obvious emulsification.

The apparent inhalation index decreased by 23%-33%, the liquid production index decreased by 31-42%, the inhalation thickness ratio of oil reservoir were 89.5%-92.7%, the water cut decreased by 16%-20%, and the enhanced recovery increased by over 20% in the weak alkali ASP flooding of the second oil reservoir.
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