Discussion on Reasonable Well Spacing of Polymer Flooding in the Second Class Reservoir of Lamadian Oilfield

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Abstract. Lamadian Oilfield entered the development stage of polymer flooding in the second-class reservoir in 2006. At present, 8 blocks of well distribution schemes have been compiled and 6 blocks have been put into production by perforation. From the well spacing adopted in the polymer flooding development block of Class II reservoir and the polymer flooding test area of Sa Ⅲ 4-10 reservoir in La'nan Area 1, the injection-production well spacing is mainly 106 m ~ 212 m. According to the current development effect of each block, the well spacing of each set has certain inadaptability. Therefore, this paper, on the premise of guiding the preparation of well distribution plan in Area 2 of Middle East Block of La’nan, discusses the reasonable well spacing of polymer flooding in the second class reservoir from the aspects of control degree of polymer flooding, well pattern density, single well controlled reserves and so on. Combined with the actual situation of the implemented polymer flooding block, it is concluded that when the injection-production well spacing is 150m, it has about 80% polymer flooding control degree for the second-class reservoir, which can ensure reasonable well pattern density and single well controlled reserves, and obtain higher recovery ratio and economic benefits.

Keywords: Second class reservoir; polymer flooding; reasonable well spacing.

1. Introduction
Lamadian Oilfield entered the development stage of polymer flooding in the second-class reservoir in 2006. According to the development idea of "reducing well spacing, one set of well pattern, subdividing layer series, developing by stages, giving priority to the second class and giving attention to the third class", the second-class reservoir will be subdivided into ten blocks and put into tertiary oil recovery development. At present, 8 well layout plans have been prepared, and 6 blocks have been put into production, including polymer flooding test area of SA Ⅲ 4-10 reservoir in Lanan 1 area. In the layer series combination, SA 3 reservoir is the first set of up flow development layer series; in the well pattern well spacing, the five point well pattern with 106m ~ 212m well spacing is mainly used. From the development effect of the put-into-production blocks, under the condition of different well patterns and well spacing, the first set of upflow series can ensure the effective development of polymer flooding, but it also has certain inadaptability. Therefore, by studying the influence of well spacing on polymer flooding control degree, well pattern density, single well controlled reserves and enhanced oil recovery,
this paper discusses the reasonable well spacing of the second-class reservoir in Lamadian Oilfield and determines the reasonable well spacing of the second-class reservoir.

2. Development status of polymer flooding blocks in second-class reservoirs with different well spacing

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According to the well spacing in the upper return block of the developed class II reservoir in Lamadian oilfield, the well spacing is mainly 212m ~ 106m. Well spacing of 212m is adopted for polymer flooding test area of la'nan-1 block, 150m well spacing is adopted for block I, II, south-central-east-1, zone 1 and zone 2 of northeast block, 120m well spacing is adopted for block I of central and Western la'nan, and 106m well spacing is adopted for block I and zone II of West Labei block. From the development effect of developed polymer flooding block in class II reservoir, polymer flooding test of SA III 4-10 reservoir in la'nan-1 area shows that polymer injection can achieve good results for SA-3 reservoir with better reservoir property under 212m well spacing, but the effective period and development effect of oil wells are quite different due to the influence of sand body development and polymer flooding control degree. The test results of block 1, block 2, block 1 and block 1 show that high concentration polymer flooding can form effective displacement and achieve good polymer flooding effect. The test results in block 1 and block 2 of West Labei block show that the proportion of directional wells and low efficiency wells increases under 106m injection production well spacing, and the polymer advance speed is too fast, which will lead to the rapid recovery of water cut after polymer flooding is effective. Therefore, combined with the above block well layout experience and development effect, it is necessary to discuss the reasonable well spacing of class II reservoir in Lamadian Oilfield in order to guide the formulation of polymer flooding well layout scheme for class II oil layer in Lamadian oilfield.

3. Discussion on reasonable reservoir spacing of polymer flooding

The current research results show that [1], with the increase of polymer flooding control degree, EOR amplitude increases. Here, firstly, the control degree under different well spacing is discussed. Secondly, the reasonable well spacing of polymer flooding in second-class reservoirs is discussed from the following aspects: well pattern density, single well controlled reserves, enhanced oil recovery and internal rate of return, etc. Combined with the actual situation of polymer flooding blocks, the reasonable well spacing suitable for polymer flooding development in second-class reservoirs is obtained.

3.1. Relationship between different well spacing and polymer flooding control degree

According to theoretical analysis, the control degree of polymer flooding in Sa iii 4-10 reservoir of Lamadian Oilfield is increasing with the reduction of well spacing. When the well spacing is 150m, the control degree of polymer flooding can reach a high level, reaching 81.5%. However, when the well spacing is further reduced from 150m, the degree of polymer flooding control is not greatly improved. In addition, according to the statistics of polymer flooding control degree under different well spacing in tertiary oil recovery block of developed second-class reservoir in Lamadian Oilfield, the control degree of polymer flooding also increases with the reduction of well spacing, and when the well spacing is 150m, the control degree of polymer flooding is about 80%. Therefore, 150m well spacing is recommended.
3.2. Relationship between different well spacing and well pattern density and single well controlled reserves

It can be seen from the statistics of polymer flooding control degree of tertiary oil recovery blocks in developed second-class reservoirs [2] that with the reduction of well spacing, the well pattern density increases and the controlled geological reserves of single wells gradually decrease. The well pattern of 212m five-point method area is adopted in La’nan Experimental Area, and the reservoir thickness is well developed, which is not representative for the whole oilfield. For 120m and 106m five-point well patterns, due to the reduction of injection-production well spacing, the well pattern density of this series has been higher than 90 wells/km². If other series of wells are considered, as well as the actual requirements of drilling technology and the deployment between surface wells and stations, there will be little room for block adjustment in the future. At the same time, the controlled geological reserve per meter of a single well is lower than 0.200×10⁴t/(mouth meter), which will lead to a significant reduction in economic benefits. Therefore, 150m well spacing is recommended.

Table 2. Statistics of different well spacings in tertiary oil recovery blocks in developed second-class oil layers in Lamadian Oilfield

| Blocks               | Target interval | Effective thickness (m) | Well pattern and spacing | Well pattern density (km²) | Controlled geological reserves of single well[10⁴t] |
|----------------------|-----------------|-------------------------|--------------------------|----------------------------|---------------------------------------------|
| La’nan test zone 1   | SA III 4-10     | 13.1                    | 212m five-point area well pattern | 35.0                       | 0.345                                       |
| Beibeikuai zone 1    | SA III4-10      | 9.8                     | 150m five-point area well pattern | 64.9                       | 0.342                                       |
| Beidongkui zone 1    | SA III4-10      | 8.8                     | 150m five-point area well pattern | 67.2                       | 0.292                                       |
| Beidongkui zone 2    | SA III4-10      | 9.1                     | 120m five-point area well pattern | 96.5                       | 0.198                                       |
| Beixi block zone 1   | SA III1-7       | 10.9                    | 106m five-point area well pattern | 93.0                       | 0.142                                       |
3.3. **Relationship between different well spacing and EOR and IRR**

By using the economic evaluation software and numerical simulation of oil and gas field development and construction projects, the EOR and after-tax internal rate of return of polymer flooding under different well spacing in Lamadian Oilfield are analyzed, and it is concluded that when the well spacing is 150m, the EOR has reached a very high standard of 13.3%. With the gradual reduction of well spacing, the EOR of polymer flooding is gradually improved, but the improvement is small and gradually reduced. From the early benefit evaluation, the internal rate of return at 150m well spacing is up to 22.1%, which is nearly twice as high as the other two sets of well spacing. Therefore, considering comprehensively, it is recommended to adopt 150m well spacing.

| Table 3. Comparison of well spacing schemes for polymer flooding in Sa Ⅲ 4-10 reservoir in Lamadian Oilfield |
| Well spacing Projects | 150m | 120m | 106m |
|------------------------|------|------|------|
| Polymer flooding enhances recovery rate (%) | 13.3 | 13.6 | 13.8 |
| Internal rate of return after tax (%) | 22.1 | 12.2 | 9.7 |

To sum up, 150m well spacing has 80% polymer flooding control degree for class II reservoir, which can ensure reasonable well pattern density and geological control reserves of single well, and can obtain high oil recovery and economic benefits. Therefore, the injection-production well spacing of 150m is recommended for polymer flooding in Class II reservoirs.

4. **References**

1. With the further shrinking of well spacing, the degree of polymer flooding control of the reservoir is continuously increasing. When the well spacing is 150m, the degree of polymer flooding control can reach a high level, all around 80%.

2. For the polymer flooding development of Type II oil reservoirs, when the well spacing is 150m, the well pattern density and single well controlled reserves are relatively good.

3. For the polymer flooding development of the second-class oil layer, it is recommended to use 150m injection-production well spacing, which can achieve higher recovery efficiency and economic benefits.

**References**

[1] Wu Wei. Determination of polymer flooding parameters for the second-class reservoir based on the degree of polymer flooding control. Journal of Daqing Petroleum Institute. 2006.

[2] Xiao Qianzhu et al. Polymer flooding reservoir engineering scheme for the second type oil layer in the second block of the North East Block of Lamadian Oilfield. July 2011.

[3] Han Jiayou. Analysis of problems and countermeasures in oilfield three-production polymer injection technology [J]. Chemical Engineering and Equipment, 2019, No. 272 (09): 116+125.

[4] Zhang Wei, Gu Yuan. Research on the Application of Fine Management in Gas Station Construction Projects [J]. Ju She, 2019, 000(027): P.123-123.

[5] Bu Wenqian, Wang Haijun, Zheng Yi. Practical exploration of using refined management to ensure the quality of medical record management [J]. Health Must Read, 2018, 000(004): 194-194

[6] Li Zhongmin. Research on fine management of oil and water wells in oilfields [J]. Chemical Engineering and Equipment, 2018, 000(003): 129-130,133.