Evaluation Method of Antiscaling Performance of Downhole Tools for ASP Flooding in Daqing Oilfield

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Abstract. At present, the technology of ASP flooding in Daqing Oilfield has entered the stage of industrialization and popularization. The total number of injection wells of ASP flooding has reached more than 4000. At present, the main problem of ASP flooding layered injection wells is that after injection of ASP compound solution for a certain period of time, the displacement effect is poor due to the sticking of scale and micelle in the partial hole and throttling element of injector A series of influences, such as the increase of the workload and the shortening of the period of measurement and adjustment, etc. However, the existing anti scaling technology mainly deals with the parts that are easy to scale, which has the advantages of high lubrication, low friction and non viscosity. However, due to the variety and different performance, it is necessary to compare and evaluate the anti scaling performance. However, the conventional coating evaluation method mainly judges the advantages and disadvantages of the coating technology through the conventional inspection indexes such as appearance size, roughness and smoothness There is no practical significance for the evaluation of the anti scaling performance of the special environment of ternary injection. Based on the field test, this paper forms a set of evaluation method for the scale prevention performance of ASP flooding, realizes the evaluation and optimization of the scale prevention performance of ASP flooding, and effectively prolongs the testing and adjusting period.

1. Introduction
Daqing Oilfield has entered the development period of ultra-high water cut stage, and it is increasingly difficult to tap the potential of remaining oil. The ASP flooding technology, which integrates strong alkali, surfactant and polymer, not only expands the swept volume, but also effectively improves the oil washing efficiency. It has become the tertiary oil recovery technology developed by Daqing Oilfield to further improve the oil recovery[1-3].

The ASP flooding technology has entered the stage of industrialization and popularization. The total number of injection wells of ASP flooding in Daqing Oilfield has reached more than 4000. The studied ASP flooding sub injection string has realized 3-5 layers of sub injection, which can inject different molecular weight and different injection volume of ASP compound solution in different layers according to the needs, so as to match the formation permeability. After adopting this technology, injection The injection profile has been significantly improved, and the statistical results of the test block show that the production degree of the reservoir has been increased by 8%, which is a promising injection technology[4-6].

At present, the main problem of ASP flooding solution flooding injection well is that after a certain time of injection of ASP flooding solution, the central channel of the injector, the deviated hole and the
throttling element lead to a series of influences such as poor displacement effect of the injection well, increased workload of measurement and adjustment, shortened period of measurement and adjustment due to the scale and adhesive mass[7,8]. The existing anti scaling technology mainly deals with the parts that are easy to scale, which has the advantages of high lubrication, low friction and non viscosity. However, due to the variety and different performance, the evaluation method of anti scaling technology or coating mainly judges the advantages and disadvantages of the technology by the conventional inspection indexes such as appearance size, roughness and smoothness. For the special feature of ternary injection into the underground, it has the advantages of high lubrication, low friction and non viscosity There is no practical significance in the evaluation of the scale control performance of different environments. It is impossible to evaluate and optimize the scale prevention technology of different processes and materials[9,10].

2. Establishment of Performance Evaluation Standards for Different Antiscaling Processes

The separate injection string of ASP flooding in Daqing Oilfield is mainly composed of eccentric injection distributor, packer, throttling element and other components. According to the geological plan, the separate injection string is put in, and each layer section is sealed and separated by packer, and each layer section corresponds to one-stage eccentric injection distributor. In the process of injection, the throttling element is put into the eccentric hole of the eccentric injector. When the ternary compound solution flows through the eccentric injector, enough throttling pressure difference can be formed, so as to reduce the injection pressure and control the injection volume of the restricted layer. At the same time, the injection pressure can be increased and the injection volume of the strengthening layer can be increased. Therefore, under the same injection pressure on the ground, the injection volume of each layer can be controlled by adjusting the injection pressure of each layer, so as to achieve the purpose of layered injection.

![Separate injection string of ASP flooding](image)

**Figure 1.** Separate injection string of ASP flooding

Through the analysis, it is considered that after the tool scaling in the injection well of ASP flooding, the biggest impact is that the scale is produced at the partial hole and throttle element of the tool, which changes the flow clearance, thus leading to the change of the flow limiting ability of the tool.

In this paper, the flow and pressure changes of throttling element under different flow gaps are tested. The results show that the throttling performance of throttling element increases with the decrease of the gap after changing the flow gap between the throttling element and the eccentric hole. For the single-layer injection volume of Daqing Oilfield is mainly 20-50 m³ / d, the test also counts the change of flow limiting capacity within the flow range, The results show that when the flow rate is 20-50 m³ / d, the over-current gap is reduced by 0.1mm, the off-site flow rate is reduced by 4.4% -
5.3%, the over-current gap is reduced by 0.3mm, the off-site flow rate is reduced by 14.4% - 24.4%, the over-current gap is reduced by 0.5mm, and the off-site flow rate is reduced by 23.8% - 42.2%.

According to the test results, when the over-current gap is reduced by more than 0.3mm, the maximum impact on the flow is 24.4%, which is beyond the range of ± 20% of the allowable error of field test deployment. According to this, the scaling judgment standard is obtained. In the specified effective downhole working period, if the scaling amount of the throttling element and eccentric injector treated by the evaluated scale prevention process in the eccentric hole results in the reduction of the overflow gap by more than 0.3mm, then the scale prevention performance of the process is judged to be unqualified.

| Clearance between throttle element and eccentric hole(mm) | Flow through(m³/d) | Flow change ratio(%) | Flow through(m³/d) | Flow change ratio(%) |
|----------------------------------------------------------|--------------------|---------------------|--------------------|---------------------|
| 1                                                        | 20                 | 0                   | 50                 | 0                   |
| 0.9                                                      | 18.94              | 5.3                 | 47.8               | 4.4                 |
| 0.7                                                      | 15.12              | 24.4                | 42.8               | 14.4                |
| 0.5                                                      | 11.56              | 42.2                | 38.1               | 23.8                |

3. Establishment of Evaluation Methods for Different Antiscaling Processes

After determining the performance evaluation standards of different antiscale processes, the evaluation methods of antiscale processes are explored from indoor and field aspects.

3.1. Indoor Evaluation

The indoor static immersion experiments of throttling elements made of different antiscale materials were carried out. The throttling elements treated by different antiscale processes were immersed in the ternary complex flooding solution of strong alkali and weak alkali respectively. The scaling amount was determined by regular observation, measurement and weighing (Fig. 2). The test results showed that after 12 months of immersion, only a few coatings of individual samples fell off, without obvious scaling (Table 2).

![Weak alkali][Strong base]

**Figure 2.** Indoor static immersion test of throttling elements with different antiscaling materials

| Soaking time | Solution type | sample 1               | sample 2               | sample 3               | sample 4               | sample 5               |
|--------------|---------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| 12 months    | Strong base   | No scaling             | No scaling             | No scaling             | No scaling             | No scaling             |
|              | Weak alkali   | No scaling             | No scaling             | No scaling             | Unfouled               | No scaling             |
The analysis shows that there are no conditions such as liquid flow and injection pressure in the test, which is quite different from the real injection environment, and the test results have no guiding significance.

3.2. Site Evaluation
In order to get the real and objective evaluation test results, the scale control technology performance comparative evaluation test tool is designed, which is composed of the upper end bailing part and the lower end test sample part (Fig. 3). The lower end test part can be connected with the samples processed with different anti scale materials in series, and the samples in series are put into the eccentric hole of the same strengthened layer eccentric injector in the same well, through the regular bailing out test Measure the scale thickness of the sample piece. After the test tool is placed in the underground reinforcement layer, because the outer diameter of the sample piece is small and the gap between the sample piece and the deviated hole is very large, there is no throttling pressure difference, so it will not affect the flow limiting capacity in the reinforcement layer. In this way, if the flow changes and the scheme does not match at the time of the measurement and adjustment cycle, only the limitation layer needs to be adjusted, and the test sample piece in the reinforcement layer can be one. It is placed in the underground for a long time, so as to realize the comparative evaluation of the performance of different antiscaling technologies under the same well condition and the same injection environment.

![Upper fishing part Lower end test sample part](image)

**Figure 3.** Test tool for performance comparison and evaluation of scale prevention process

The test results show that the thickness of scale formation in samples 2, 3 and 4 is more than 0.6mm within the specified validity period of 6 months, which results in the influence of overflow gap > 0.3mm. If the samples are used as throttling elements and eccentric injection allocators, the injection error will be up to 24.4%, which is not recommended; the scale formation in samples 1 and 5 is less than 0.2mm, which affects overflow gap < 0.1mm, and the influence of injection volume is less than 5%, which can be used as downhole coating Use of tool anti scaling process (Fig. 4).

![Comparison curve of scaling amount change](image)

**Figure 4.** Comparison curve of scaling amount change

4. Field Verification
The scale control process optimized by the evaluation was verified in the ternary block of Daqing Oilfield. The original process string in the selected test well was not treated by the scale control process, and the test and adjustment period was only 3 weeks. After the tool was treated by the optimized scale control and scale control process, the scale condition was significantly improved, and
the longest service period was more than 8 months, which fully met the existing Daqing Oilfield test demand of two month test and adjustment period for injection well of ASP flooding in oil field.

5. Conclusion
(1) According to the change of the flow rate of throttling element under different flow clearance, the scaling criterion of antiscaling performance is determined, that is, if the scaling amount of throttling element and eccentric injector treated by the evaluated antiscaling process causes the flow clearance to be reduced by more than 0.3mm during the specified effective downhole working period, the antiscaling performance of the process is determined to be unqualified at this time.

(2) There is a big gap between the indoor immersion method and the actual well condition. The laboratory can not fully simulate the conditions such as sewage allocation, long-term non circulation flow of liquid, injection under pressure, etc., so the indoor test evaluation results are far from the real situation, which has no guiding significance.

(4) The field evaluation method realizes the comparative evaluation of the performance of different antiscaling technologies under the same well condition and injection environment, and the objectivity of the evaluation results is verified by field verification.

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