Analysis of influencing factors of stimulated reservoir volume (SRV) and zipper fracturing simulation in shale oil reservoirs of Hu326 Well area

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Abstract. Horizontal Well SRV of intensive stage and high–intensity for shale oil reservoirs of Hu326, which are different beddings and develop natural fractures locally, is conducive to the formation of complex fracture network with the intersection of main fractures, natural fractures, bedding fractures and other secondary fractures. At present, although there are systematic theories and methods for the study on the extension of hydraulic fracture after intersecting natural fractures and bedding planes, there is no quantitative research on specific parameters, and the research results are not applicable to actual exploitation. Based on the characteristics of shale oil reservoirs and combined with the theory of formation strength with weak surface, this article discusses the formation mechanism of fracture network of jimusar shale oil reservoir and improves the extension law of hydraulic fractures after intersecting with natural fractures and bedding planes. And taking the jimusar shale oil reservoir as the object, the extension law of hydraulic fracture is analysed and the geomechanical influencing factors and engineering control parameters of SRV are determined. The research results provide theoretical basis and parameter guidance for SRV of jimusar shale oil reservoir.

Keywords: shale oil reservoirs of Hu326 Well area; natural fractures; intersection criteria; true 3D simulation.

1. Introduction

Hu326 Well area is located in the An83 block of Changqing Oilfield with shale oil, whose Chang-7 oil reservoir is a layer reservoir which has no obvious oil-water interface and the water layer distribution is affected by multiple factors such as lithology, physical property and structure.

The volume fracturing technique provides a new way to develop shale reservoirs on a large scale. Guo Peng [1] used RFPA-flow software to establish a fluid-solid coupling model of reservoirs and...
simulate fracture propagation. Wang Zhen [3] developed a fracture propagation program to simulate the effects of hydraulic fracture propagation and stress interference on fracture propagation, and discussed the effects of net pressure, horizontal principal stress difference and different fracture modes on fracture morphology and deformation. The research results of Weng Dingwei [6] showed that natural fractures are the most important factor for the formation of complex fractures. The influence factors of reservoir stress difference, natural fracture and artificial fracture are analyzed. From the perspective of fracture spacing, conductivity of primary and secondary fractures, and fracture morphology.

Based on shale oil reservoir in Hu326 Well area, an influence factors analysis model of SRV with 3 clusters in single-segment and multi-cluster in multi-segment is built, which is based on unconventional UFM fracture network model and the practical geological model and geomechanical model of Jianping Well 10. The influence of engineering control parameters of SRV is studied and the artificial fracture extension and fracture network extension is simulated to confirm optimum parameters of SRV.

2. Zipper fracturing and simulation method for Jianping Well 5-6 in Hu326 Well Area
Jianping Well 5 and Well 6 are located in The Hu326 well area whose main layer is 71 and adopt development method with natural energy of long horizontal Wells.

Jianping Well 5 and Well 6 well adopt sand fracturing with "multi-cluster perforation, high displacement and large fluid volume" was applied to increase the complexity of fractures, expand the volume of SRV and improve the production of single well and zipper fracturing to realize the cross coverage of the reconstruction volume between well groups to increase the complexity of the fracture network and the reconstruction volume of artificial fracture reservoir.

The SRV technology with DMS soluble seat and subdivision cutting is applied for decreasing cost and increasing benefit. UFM can simulate fracture propagation, deformation and fluid flow in complex fracture networks, taking into account fluid flow and elastic deformation of fractures in fracture networks. UFM also takes into account the interactions between adjacent hydro-fracture.

![Unconventional fracture model of SRV.](image)

3. Study on the Parameter Optimization of SRV in Hu326 Well area
The influencing factors of fracture propagation were studied by comprehensively referring to the geological characteristics and fracturing design of adjacent Wells in Block Hu 326.

The main research factors are as follows:
- Displacement: $4m^3/min$, $6m^3/min$, $8m^3/min$, $10m^3/min$, $12m^3/min$.
- Net liquid volume: $400~1300m^3$.
- Sand concentration: $5\%$, $10\%$, $15\%$, $20\%$, $25\%$.
- Number of clusters: $1, 2, 3, 4, 5$.

Change the displacement to simulate the volume transformation of artificial seam network.
Figure 2. Influencing factors analysis of displacement.

According to the Figure 2, with the increase of displacement, the height presents an overall trend of increasing, and finally decreases slightly. When the slit length reaches the maximum displacement of $8 \text{ m}^3/\text{min}$, then decreases. The supporting area and reconstruction volume first increase and then decrease, and about $8 \text{ m}^3/\text{min}$ is the optimal value.

Change the net liquid volume to simulate the volume transformation of artificial seam network.

Figure 3. Influencing factors analysis of net liquid volume.

According to the Figure 3, the height, length, support area and modified volume of fractures show an overall trend of increase, but over $800 \text{ m}^3$, some parameters show a trend of decrease. From the perspective of support area and fracture volume, the net liquid volume of $700 \text{ m}^3-800 \text{ m}^3$ is the best.

Change the sand concentration to simulate the volume transformation of artificial seam network.
Figure 4. Influencing factors analysis of sand concentration.

The comprehensive analysis combined with specific geomechanical situation of the reservoir from the support area and support volume shows that the sand concentration of 15%-20% of the fracture in the optimal fracture network is the optimal design value.

4. Study on cluster spacing Optimization for SRV in Hu326 Well area

For segmented clustering optimization, the horizontal segment of 1500 meters is divided into 21 segments, and single segment has 2, 3, 4 and 5 clusters to simulate the volume transformation of artificial seam network.

Table 1. Simulated data of cluster spacing optimization in SRV

| Clusters | Length (m) | Width (mm) | Height (m) | Support area (m²) | Support volum (m³) | Cluster spacing (m) |
|----------|------------|------------|------------|-------------------|-------------------|-------------------|
| 2        | 118.17     | 10.23      | 35.20      | 7588.66           | 108.12            | 29.12             |
| 3        | 135.95     | 8.44       | 36.14      | 8058.00           | 112.76            | 19.54             |
| 4        | 112.74     | 11.92      | 29.99      | 5809.50           | 118.51            | 14.70             |
| 5        | 122.32     | 14.54      | 30.03      | 4820.47           | 135.52            | 11.79             |

Figure 5. Simulated result of cluster spacing optimization in SRV.

From the simulation results, it can be seen that with the increase of the number of clusters, the support area and the modified volume of fracture network increase significantly from 2 clusters to 3 clusters. However, from 3 clusters to 4 and 5 clusters, due to the small spacing of clusters and serious interference between the fractures, the support area decreases significantly and the support volume increases. Therefore, the optimal number of clusters is 3, and the corresponding cluster spacing is 15-20 meters.

In conclusion, the geological model and geomechanical model of Well Hu 326 were adopted to complete the integrated simulation of zipper fracturing in Jianping well 5-6.
5. Conclusion

(1) According to the zipper fracture design of Jianping Well 5-6, an artificial fracture network model of SRV with integration of geological engineering was established by UFM network model. And the optimization of construction parameters such as displacement, fluid volume, sand concentration and cluster spacing was carried out.

(2) The research results of subsection fracturing construction parameter optimization of horizontal Wells in Hu326 Well area show that, the optimized displacement of a single cluster is 4m³/min, the fluid volume is 350-400m³, the sand concentration is 15%-20%, and the spacing between clusters is 15-20m.

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