Water and Electronic Simulated Experiment Study of Volume Fracturing Horizontal Wells in the Tight Oil Reservoir

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Abstract—Based on characteristics of tight oil reservoir and micro-seismic monitoring data of the volume fracture, the experiment of water and electricity simulation demonstrated the feasibility of fractured horizontal well in tight oil reservoir through productivity features and seepage field of different well-type and firstly analyze the productivity influence of the size of stimulated volume of reservoir and reservoir synthetic stimulated factor on volume fractured horizontal well. The study has shown that volume fracturing can largely reduce the percolating resistance of the zone near the wellbore, the productivity of volume fractured horizontal well is apparently higher than horizontal well and conventional fractured horizontal well, and the larger the size of stimulated volume of reservoir and the bigger of the reservoir synthetic stimulated factor , the higher the initial production productivity of the volume fracturing horizontal wells.

Index Terms—tight oil reservoir; volume fracturing; horizontal well; Water and electronic simulated experiment;

I. INTRODUCTION

High price of oil and gas, the exhaustiveness of conventional oil and gas and the badly need of people for oil in recent years encouraged businessmen to explore the development of unconventional oil and gas. The resourceful unconventional oil and gas reservoirs can replace of conventional oil and gas reservoirs thereby the development of tight oil and other unconventional resources will produce huge influence on energy structures in future [1].

Due to bad property of tight oil reservoir and the high percolation resistance the method based on conventional vertical wells hardly explore any industrial oil. The technology of horizontal well and hydraulic fracturing stimulation is the key to successfully develop unconventional oil and gas reservoirs [2] and [3]. Micro-seismic monitoring data attested that after hydrofracturing of horizontal well it can forms a complicated fracture network in the area near the well, magnify the drainage area, reduce the percolation resistance and finally improve individual well deliverability. In this way, the reasonable matching of tight reservoir, horizontal well and fracturing parameter are the guarantee of increasing individual well deliverability.

The research method of of fracturing of horizontal fracture shape optimization are mainly include mathematical theory deduction and the electric simulation method. The establishment of mathematical model is based on volumes of idealized assumptions which can hardly reflect the practical situation of oil reservoirs [4]-[6]. The research contents of existing electric simulation method are confined in these aspects such as single well fracture number, fracture length, fracture angle and Isobar shape without take the interaction of artificial fracture and nature fracture into consideration [7], [8].

This paper works out an electrical simulation scheme of volume fractured horizontal well by the utilization of new conducting medium in the basis of the features of tight oil reservoirs and micro-seismic monitoring data of the volume fracture [9]. It not only analysis the percolation characteristics of volume fractured horizontal wells in the condition of considering the effects of natural micro fracture but also testified the feasibility of volume fracturing horizontal well development of tight oil reservoir and analyze the factors influence on volume fractured horizontal well from a new perspective which severed as reference to the optimization of fracturing parameter of horizontal well.

II. EXPERIMENT PRINCIPLE AND DEVICE

Water and electronic simulated experiment shows the steady seepage field in porous medium through constant current in conducting medium and in the basis of simulated principles and criterion. The shape and distribution of seepage field are the same with electric field which all can get similar solutions under the similar boundary conditions. The device of the electronic simulated experiment involves oil reservoir simulation system, low-voltage circuit system and measuring system [10]. At present a wealth of tight oil reservoirs are developed from horizontal well, which laid a foundation for horizontal well become the research target of this paper.

Electrolytic cell, with a thin cooper belt inside, is an organic glass container in square-just like Fig. 1. (C6H5O10)n, a kind of semisolid, can be simulated the
shaft of oil well by use of constantan wire, imitated artificial cracks by red copper sheet and analog nature fracture by ultrafine copper wire. Artificial fracture and nature fracture coupling into volume fracture zone, with various cracks, where can be embedding CuSO4 (a kind of liquor) with different conductivity in order to describe the matrix permeability change. Oil reservoir and model parameter are listed in Table I, and the fracture interval of conventional fractured horizontal well is 120m as well as the crack spacing of every stage of volume fractured horizontal well is 20m.

Figure 1. Experimental device.

<table>
<thead>
<tr>
<th>parameters of reservoir</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>reservoir area (length×width)</td>
<td>1200m×1200m</td>
</tr>
<tr>
<td>reservoir thickness</td>
<td>24m</td>
</tr>
<tr>
<td>producing pressure drop</td>
<td>20MPa</td>
</tr>
<tr>
<td>permeability</td>
<td>0.18×10^{-3}μm²</td>
</tr>
<tr>
<td>viscosity of Crude oil</td>
<td>1.5mPa•s</td>
</tr>
<tr>
<td>length of horizontal well</td>
<td>600m</td>
</tr>
<tr>
<td>length of artificial fracture</td>
<td>300m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>parameters of experiment</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>area of experiment model</td>
<td>80cm×80cm</td>
</tr>
<tr>
<td>thickness of the electrolyte</td>
<td>0.8cm</td>
</tr>
<tr>
<td>potential difference</td>
<td>20V</td>
</tr>
<tr>
<td>conductivity of the electrolyte</td>
<td>80μS/cm</td>
</tr>
<tr>
<td>conductivity of SRV</td>
<td>16mS/cm</td>
</tr>
<tr>
<td>length of horizontal well</td>
<td>40cm</td>
</tr>
<tr>
<td>length of artificial fracture</td>
<td>20cm</td>
</tr>
</tbody>
</table>

TABLE I. THE PARAMETERS OF PRACTICAL RESERVOIR AND EXPERIMENT.

III. ANALYSIS AND DISCUSSION OF EXPERIMENTAL RESULTS

A. Pressure Field Features of Different Well-type

This experiment simulates the pressure distribution of horizontal well, conventional fractured horizontal well and volume fractured horizontal well (Fig. 2). We can acquire following results through the isobar of different well-type.

- The isobar near wellbore area of horizontal well is in the shape of concentric ellipse cluster, the isobars of fractured horizontal well mainly affected by fracture shape and isobar of conventional fractured horizontal well Convex toward the shaft due to fracture interference while the fracturing transform zone of the volume fractured horizontal well can placid the phenomenon that the isobar convex toward the shaft; the isobars besides the fracture telos of horizontal well and horizontal well shaft are much more intense and the isobars far away from the well are mainly influenced by the edge.

- Fracturing transform zone can enlarge the drainage area of horizontal well which much less than that of fractured horizontal well. And the volume fractured transformational zone formed near the volume fractured horizontal well can reduce the percolating resistance of the near wellbore area in a tremendous degree.

Figure 2. The isobar of different well-type.

- From the near wellbore area to the supply boundary the density of isobars decreases as well as the pressure gradient. In addition to, owning to the too small pressure gradient of the outer area the main liquid source of the producing well derives from the reserve utilization of the near wellbore area.

B. Productivity Contrast of Different Well-type

The diverse productivity simulated by the water and electricity simulation experiment and their productivity produced by practical tight oil reservoir are listed in Fig. 3. Fig. 3 shows that the reservoir physical property of tight oil reservoir performs bad through only explored by horizontal well with low individual well deliverability and the reserve which hard to use; the conventional fracturing forms a single side seam in the near wellbore area and improve the individual well deliverability by expand the drainage area and chang the seepage form; further more volume fracturing, forms fracturing...
transform zone in the near well-bore area, hugely increase the initial deliverability and utilization effects by expand the drainage area and promote the near wellbore percolation environment.

C. The Analysis of the Factors Influence the Deliverability of the Volume Fractured Horizontal Well

On account of the bad reservoir physical property of tight oil reservoir, artificial fracturing system is the main gallery for oil reservoir to supply output to shaft, so fracturing parameter is the decisive factor for the yield of the producing well. Many scholars have conducted abundance research on the productivity factors of the conventional fractured horizontal well but many of which only referred single side seam as the study object. However this paper, combined with fracturing process parameter and the features of the tight oil reservoir, studies the influencing factor on productivity of the producing well from a new perspective based on the volume fracturing transform zone formed in the near well bore area by artifical and nature fracturing.

1) The Influence of SRV Size on Productivity

M. K. Fisher and other people, regard the massive hydraulic fracturing of shale gas reservoir as research object, put forward that artifical fracture and nature fracture could coupling into complicated fracturing net accroding to the micro-seismic monitoring data which laid a foudnation for them to furtherly came up with the concept of volume fracturing. In addition, they also figured out the impacts of horizontal section length, fracturing series and fracturing length on the size of volume fractured horizontal well [11] [12]. Based on above studies this thesis analysis how the size of SRV influence on the productivity of producing well and point out that SRV is mainly affected by fracture density and length in the basis of the study of fixed length of horizontal well. As the fig. 4 listed, the larger size of the stimulated volume of reservior and the drainage area the higher of the intial deliverability of the volume fractured horizontal well. Therefore, we should make efforts to enlarge the scope of reservoir stimulated zone combined with the fracturing parameter optimized by economic condition.

2) The Effects on Productivity Produced by Reservoir Synthetical Stimulated Factor

In order to correctly describe the improvements of the near wellbore area caused by volume fracturing the definition of the reservoir synthetical stimulated factor $K^S$,the ratio between the permeability (of the near wellbore fracturing transform zone which aroused by different fracturing technology, fracturing fluid and propping agent) and original reservoir property permeability is put forward. Fig. 5 manifests that the larger the reservoir synthetical stimulated factor the higher the initial deliverability of the volume fractured horizontal well.

IV. CONCLUSION

In this paper, water and electronic simulated experiment was implemented based on a new perspective. The key conclusions of this work can be summarized as follows:

- The isobar near wellbore area of horizontal well is in the shape of concentric ellipse cluster ,the isoba of fractured horizontal well mainly affected by fracture shape, and the isobar far away from the well are mainly influenced by the boundry. What is further that from near wellbore area to the supply boundary the density of
isobars decreases as well as the pressure gradient. In addition to, owning to the too small pressure gradient of the outer area the main liquid source of the producing well derives from the reserve utilization of the near wellbore area.

- First of all the reservoir physical property of tight oil reservoir performs bad through only explored by horizontal well with low individual well deliverability and the reserve which hard to use. Then the conventional fracturing forms a single side seam in the near wellbore area and improve the individual well deliverability by expand the drainage area and chang the seepage form. Further more volume fracturing, forms fracturing transformational zone in the near wellbore area, hugely increase the initial deliverability and utilization effects by expand the drainage area and promote the near wellbore percolation environment.

- The larger of the size of the stimulated volume of reservoir and the reservoir synthetical stimulated factor the higer of the productivity of the volume fractured horizontal well.

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REFERENCES


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