Optimization design of oil well fracturing scheme in X block of Daqing Oilfield

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Abstract: With the continuous development of oil fields, the remaining oil in conventional old oil fields is gradually reduced after long-term water drive development. Fracturing can change the original water drive flow channel and increase the oil production of oil Wells. After long-term water flooding development, the oil production of oil Wells in Block X of Daqing oilfield has gradually decreased, and fracturing is needed to increase production. However, Block X has three target reservoirs, and the two formations are close to each other, so stratified fracturing cannot be realized by conventional stage fracturing technology. Therefore, flow limiting method is needed to control the fracture initiation of oil formations. And each layer can be better used. The overall fracturing effect is poor, and it is necessary to carry out a separate optimization design for the control technology of fracture height. The overall fracturing sequence is: first press the third stage, then press the first stage and the second fracturing stage. There is no interference between the 19th layer and the 20th layer, and the fracturing effect is good. For the 19th small layer, the fracture half-length is about 48m, and the 20th small layer half-length is about 55m, which achieves the expected fracturing effect.

1. INTRODUCTION

For the current oilfield development, fracturing is the most effective stimulation measure[1]. For the formation with multiple intervals, different fracturing processes are generally used for stratified fracturing, mainly including conventional flow-limiting fracturing[2], pumped bridge stage fracturing, packer ball fracturing and other stratified fracturing methods[3]. Among them, flow-limited fracturing is the earliest layered fracturing method. Because multiple layers are simultaneously fractured in the process of flow-limited fracturing, fractures and fracture time affect each other[4].

After long-term water flooding development, the oil production of oil Wells in Block X of Daqing oilfield has gradually decreased, and fracturing is needed to increase production. However, Block X has three target reservoirs, and the two formations are relatively close to each other. Therefore, stratified fracturing cannot be realized by conventional stage fracturing technology, so it is necessary to adopt flow limiting method to control the fracture initiation of oil formations. And each layer can be better used. This paper utilizes the stimplan fracturing software to simulate the fracturing of a typical well group in Block X of Daqing Oilfield by the flow-limiting method, and provides a construction plan for the

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reservoir modification process. The calculation results can fully guide the fracturing construction process in the field, and the research method can effectively provide technical support for the production enhancement measures of the reservoir.

2. GEOLOGICAL SURVEY ANALYSIS OF BLOCK X

When the horizontal stress difference coefficient is 0-0.13, hydraulic fracturing can form complex fractures or network fractures. When the horizontal stress difference coefficient is 0.13-0.25, hydraulic fracturing can form more complex fractures at high net pressure. When the difference coefficient of horizontal stress is greater than 0.5, hydraulic fracturing can not form complex fractures. The average difference coefficient of horizontal stress in the block is 0.079, which can form complex cracks （shown in table 1）.

Table 1 Ground stress data table in adjacent areas

No.	Well Section(m)	Ground stress Azimuth(°)	Horizontal ground stress(MPa)	
			Horizontal	vertical
1	1490.0-1497.4	80	37.4	32.9
2	1498.0-1510.0	70	38.0	27.5
3	1510.0-1516.0	70	37.8	28.8
4	1517.0-1539.0	70	37.8	31.0
5	1544.4-1548.6	60	35.9	28.4
6	1550.6-1563.6	70	33.2	25.7
7	1564.6-1572.0	60	33.8	26.0
8	1572.0-1579.0	80	35.6	28.8
9	1580.4-1589.4	70	40.3	30.5

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No.	Well Section(m)	Ground stress Azimuth(°)	Horizontal ground stress(MPa)	
			Horizontal	vertical
10	1590.0-1594.0	60	34.0	28.7
11	1594.6-1605.6	60	40.1	31.9
12	1606.4-1611.0	60	40.8	32.7
13	1613.0-1620.0	60	34.3	26.5
14	1621.0-1623.8	60	31.7	26.6
15	1625.0-1635.0	70	40.5	30.0
16	1636.4-1645.2	65	40.1	33.6
17	1645.2-1653.6	80	40.3	33.5
18	1654.0-1669.8	55	34.6	30.1
19	1671.6-1680.0	55	33.4	28.9
average		66	36.8	29.6

In general, Young's modulus is 10-80GPa and Poisson's ratio is 0.2-0.4. It is believed that the larger Young's modulus is, the smaller Poisson's ratio is, the higher the fragility and complexity of fracturing fractures, and the lower the vice versa. It can be seen that the Young's modulus of the target interval is between 24-68GPa, and the Poisson's ratio is between 0.129-0.275.

According to the relationship between the horizontal principal stress and the vertical principal stress in the adjacent area, it can be judged that the vertical fracture structure at 1490m-1491.6m is basically vertical fracture structure, but it can not be judged at 1220m-1280m fracture structure. However, the stress change trend can be analyzed according to the stress gradient change law, and the change between the vertical and horizontal principal stress at the target well interval can be predicted. The average sandstone thickness of a single well drilled in this area is 57.95m, and the effective thickness is 23.93m. From the subdivision, the sandstone thickness of D2 layer is 22.31m, the effective thickness is 13.02m, and the drilling rate of channel sand is 30.98%. D1a small layer sandstone thickness 25.11m, effective thickness 8.78m; D1b small layer sandstone has a thickness of 9.46m, an effective thickness of 2.81m, and a drilling rate of 17.08%.

According to the logging curve, the formation stress, Young's modulus, Poisson's ratio and brittleness index corresponding to the depth of the reservoir are analyzed to find out the corresponding data at different positions of the reservoir, and the formation pressure distribution law is calculated according to the test production data and formation pressure analysis results.

The actual pressure gradient of the reservoir can be obtained as 0.0053MPa/m, while the pressure gradient of the overlying reservoir is 0.018MPa/m, the reservoir pressure is about 10.5MPa, and the overlying stress of the reservoir is 20.36MPa（shown in figure 1）.

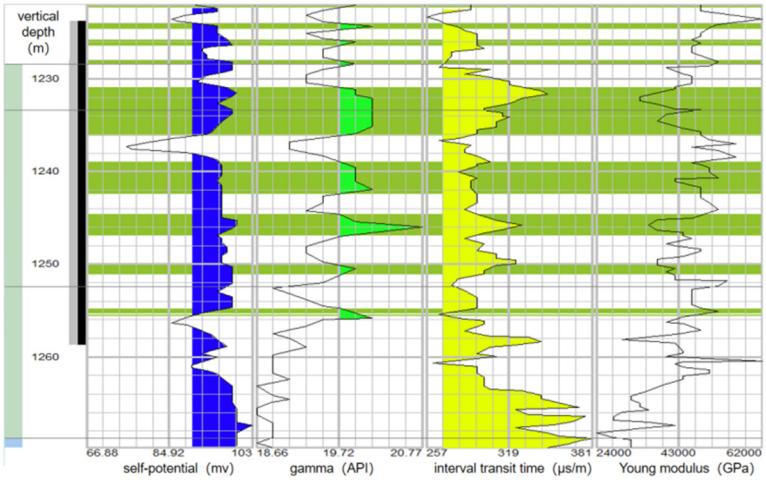


Figure 1 Formation pressure prediction and pressure gradient correction based on logging curves

Young's modulus and Poisson's ratio are the main rock mechanical parameters to characterize brittleness, and the characteristics of high Young's modulus, low Poisson's ratio and brittleness failure are the necessary conditions for reservoir compressibility[5]. Poisson's ratio can reflect the change of stress and elastic modulus can reflect the ability of maintaining crack propagation. Brittleness is a comprehensive property of materials, which is the ability to produce internal non-uniform stress under its own natural heterogeneity and external specific loading conditions, and lead to local failure, and then form a multi-dimensional fracture surface. To characterize brittleness, it is necessary to establish a specific brittleness index. It is generally believed that the higher the brittleness index is, the more likely it is to generate network cracks. The Young's modulus of the interval ranges from 24 to 68GPa, Poisson's ratio ranges from 0.129 to 0.275, and the brittleness index ranges from 24.24 to 46.96.

3. OPTIMIZATION OF FRACTURING SCHEME IN BLOCK X

Fracturing software is used to simulate whether pressure channelling will occur if comprehensive fracturing is performed under the formation conditions of the target well, and fracturing sequence and construction procedures are optimized according to the simulation results. The change law of total fracture width, effective fracture width, conductivity of sand-filled fracture and fracturing fluid loss in the first, second, third and fourth stages of the general fracturing process is analyzed[6]. The general post-fracturing simulation results are shown in figure 2:

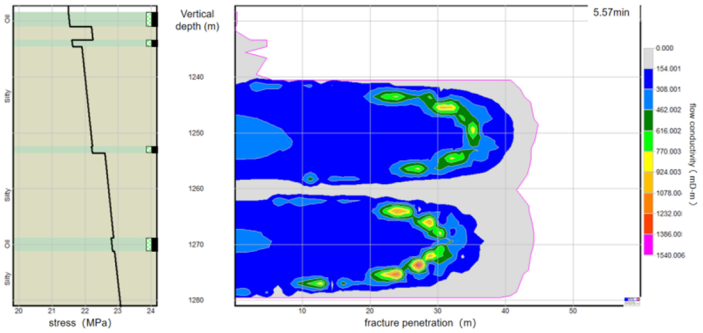


Figure 2 General fracturing simulation results

According to the simulation results, it can be seen that after general fracturing, there will inevitably be fracture interference between fractures, and the interference is serious. The first and second stages will be affected by the third and fourth stages in the fracturing process, and the last effective fracture half length is less than 10 meters, so it is necessary to perform staged fracturing simulation. In addition, as can be seen from Figure2, The fracture conductivity after fracturing is mainly affected by the proppant distribution, so the proppant distribution in the formation should be ensured to ensure the fracture has a certain conductivity during the fracturing simulation.

Stratified fracturing was carried out on the first and second stages, and the distribution of fractures after fracturing was observed. The specific simulation results are shown in Figure 3.

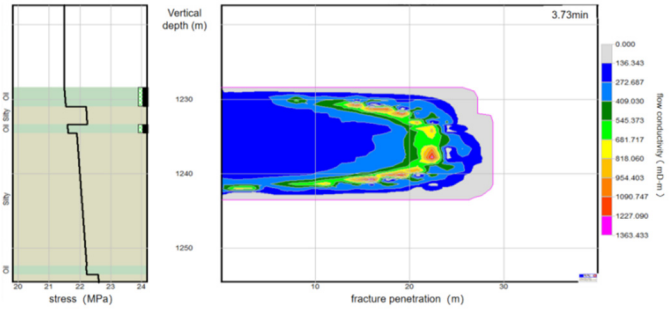
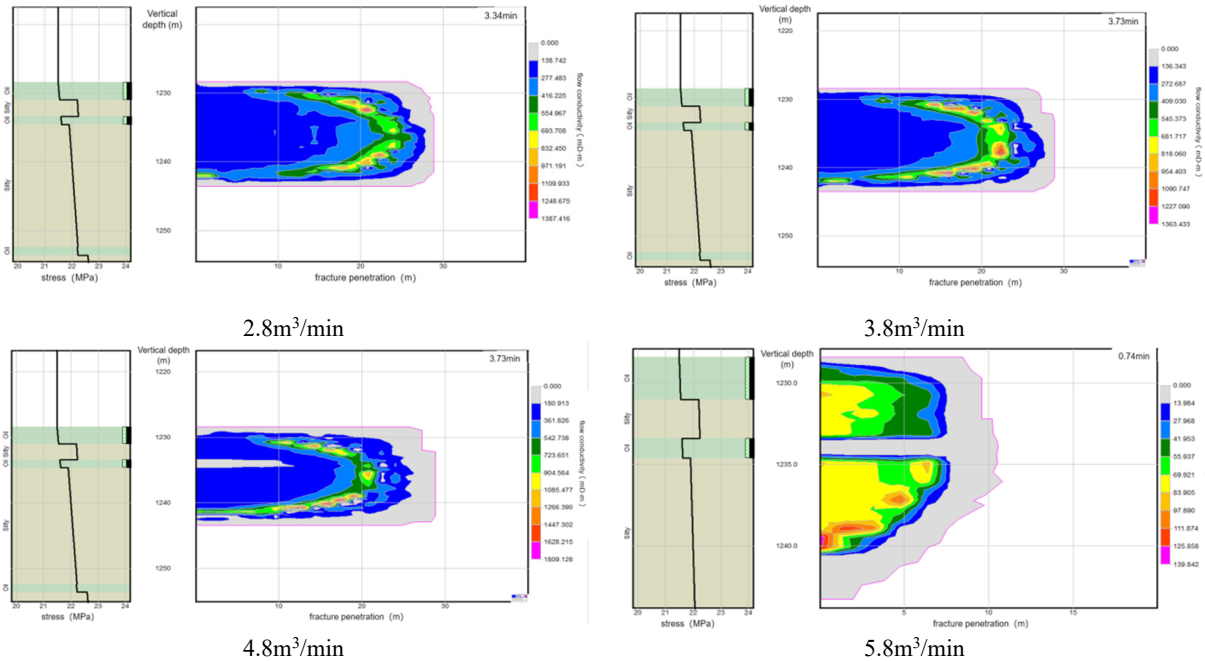


Figure 3 General fracturing of the first and second stages

According to the simulation results, it can be seen that the interference between fractures after fracturing is significantly reduced, and the overall fracturing effect is relatively good.

The numerical simulation study on the effect of construction displacement on the effective fracture width was carried out to simulate the change of the effective fracture width after sand removal and fracture closure. The simulation results are shown in figure 4.



2.8m^3/min 3.8m^3/min

4.8m^3/min 5.8m^3/min

Figure 4 The change of seam width under different pumping speed

According to the simulation results, when the pumping speed is less than 2.8m^3/min, the fracturing fluid loses more, the proppant loses more during the flowback process, the effective fracture width is narrow,

and the conductivity is reduced. When the pumping speed is greater than 3.8m^3/min, the fracture height is too high under unrestricted conditions, and the effective fracture half-length is less than 10m after fracturing, and the fracturing fails. Finally, according to the site construction situation, the construction displacement is determined to be 2.8m^3/min-3.8m^3/min.

According to the simulation results, the overall effect is poor in the fracturing process, and the focus is on the control of fracture height, so it is necessary to carry out a separate optimization design for the control technology of fracture height, and the overall fracturing order is: first pressure the third stage, then pressure the first stage and the second fracturing stage. According to the simulation results, the construction parameters are determined in table 2 and table 3:

Table 2 19th, 20th layers pumping procedures

No.	Stage Liquid volume	Stage type	Pumping rate	Fluid type	Proppant type	Proppant concentration
1	30	Lead fluid	3.0	Fracturing fluid	-	0
2	10	proppant	3.0	Fracturing fluid	silica sand	40
3	10	proppant	3.5	Fracturing fluid	silica sand	80
4	10	proppant	3.5	Fracturing fluid	silica sand	120
5	10	proppant	3.5	Fracturing fluid	silica sand	160
6	10	proppant	3.8	Fracturing fluid	silica sand	200
7	14	Displacing fluid	3.8	Flushing fluid	-	0

Table 3 21th layer Pumping procedures

No.	Stage Liquid volume	Stage type	Pumping rate	Fluid type	Proppant type	Proppant concentration
1	28	Lead fluid	3.0	Fracturing fluid	-	0
2	8	Lead fluid	3.0	Fracturing fluid	silica sand	40
3	8	Lead fluid	3.5	Fracturing fluid	silica sand	80
4	8	Lead fluid	3.5	Fracturing fluid	silica sand	120
5	8	Lead fluid	3.5	Fracturing fluid	silica sand	160
6	8	Lead fluid	3.8	Fracturing fluid	silica sand	200
7	14	Displacing fluid	3.8	Flushing fluid	-	0

4. CONCLUSION

(1) The formation brittleness index is higher, the Young's modulus is higher, the difference coefficient of ground stress is smaller, the bedding fractures are developed, and the reservoir compressibility is better.

(2) A separate optimization design is carried out for the control technology of fracture height, and the overall fracturing order is: first pressure the third stage, then pressure the first stage and the second fracturing stage.

(3) There is no interference between the 19th and 20th layers, and the fracturing effect is good. For the 19th small layer, the fracture half-length is about 48m, and the 20th small layer half-length is about 55m, which achieves the expected fracturing effect.

(4) The calculation results can comprehensively guide the field fracturing construction process, and the research method can effectively provide technical support for reservoir production enhancement measures.

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