Optimization of construction parameters for fractured horizontal wells in the southern block of eastern Sulige gas field.

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Abstract. Sulige gas field is a typical tight sandstone gas reservoir. Single well stimulation is an effective means of late fracturing. Because of the complex geological conditions in the Sulige area, there is little research on fracture parameter design of fractured horizontal wells. Based on the geological and engineering parameters of fractured horizontal wells in the block, the numerical simulation method is used to analyze the block. It is clear that the main controlling factors affecting the fracturing effect in the well area are fracture conductivity, fracture length, and fracture cluster number, and the optimal scheme to improve the single well production is proposed.

1. Introduction
Sulige gas field is located in the Suligemiao area in Ordos City, Inner Mongolia, and is one of the largest gas fields found in China. The gas-bearing layer is the 8th member of the Lower Shihezi Formation in Permian. The 8th member of the Shihezi Formation is a typical tight sandstone gas reservoir with a large scale. For low permeability reservoirs, single well stimulation is an effective means of late fracturing. After fracturing, horizontal wells can open new fluid flow channels in the reservoir, communicate untapped oil and gas reservoirs in a wider range, greatly increase oil and gas production and improve the recovery degree of the reservoir. The theoretical practice has proved that the optimization of fracture parameters for fractured horizontal wells is of great significance to the efficient development of horizontal wells. Although a large number of statistical analysis of post-fracturing effect has been carried out in the early stage, most of them are based on single factor qualitative analysis, and the analysis results are relatively one-sided. Therefore, in order to guide the development of horizontal wells in the Sulige gas field, through the comprehensive analysis of geological parameters and engineering parameters of pre-fracturing wells, the numerical simulation method is used to optimize the construction parameters of fractured horizontal wells in this area, so as to further improve the pertinence of fracturing design and single well production.
2. Different types of reservoir characteristics

According to different sedimentary types, the well groups are divided into three different reservoir types: Type I, Type II, and Type III. Among them, Jing 72-59H2 is the main well for Type I reservoirs, and the sedimentary type is central bank sedimentation. Jing 72-59H2 He 8_Lower 2 gas layer thickness is 9.7m, porosity is 8%, gas saturation is 74.8%, horizontal section is 1405m, sandstone is 1198m, gas layer length is 1090m, average gas measurement is 9.0441%, the test gas daily gas production is 263,600 cubic meters/day, the unimpeded gas production is 188.0451×10⁴ m³, the cumulative gas production is 1442.0813×10⁴ m³, the production days are 174 days, the stage pressure drop rate is 0.037MPa/d, unit pressure drop The gas output is 212.9×10⁴ m³/MPa.

The type II reservoir is mainly Jing 73-34H2, sedimentary type is channel sand body, Jing 73-34H2 He 8_Lower 2 gas layer thickness is 6.6m, porosity is 8.9%, gas saturation is 58.9%, horizontal section is 1356m, The sandstone is 1061m, the gas layer length is 752m, the average gas survey is 1.6952%, the dynamic reserve is 0.3838×10⁸ m³, the gas production is 97786 million cubic meters per day, unimpeded 52.5785×10⁴ m³, the cumulative gas production is 532.9296×10⁴ m³, and the production days are 134 days. The pressure drop rate is 0.07MPa/d, and the gas production per unit pressure drop is 55.7×10⁴ m³/MPa.

The type III reservoir is mainly Jing 72-63H2, the sedimentary type is channel edge, Jing 72-63H2 He 8_Lower 2 gas layer thickness is 6.5m, porosity is 9.8%, gas saturation is 49.6%, gas layer length is 367m, The average gas survey is 5.6296%, and the dynamic reserve is 0.2868×10⁸ m³.

a. Log-while-drilling curve for Jing 72-59H2 ( type I reservoir )
b. Log-while-drilling curve of Jing 73-34H2 (type II reservoir)

c. Drilling while drilling curve of Jing 72-63H2 well (type III reservoir)

Figure 1. Main well while drilling curves of different types of wells

Referring to the field geological data, according to the geological parameters of different reservoir types and the construction parameters of typical wells in different types of reservoirs, three different types of typical wells are designed. The horizontal sections of Class I, Class II, and Class III reservoirs are designed to be 1500 m, 1300 m, and 1000 m, respectively. The mathematical model of fracture length is 120-200m, cluster number is 2-6 clusters, segment spacing is 30-110m, conductivity is 250-450mD·m is designed to carry out numerical simulation optimization.

3. Optimization of fracture conductivity in different reservoirs
Class I reservoirs are designed on the basis of different types of reservoirs; Class II reservoir; Class III reservoir, horizontal section length of 1000m, 1300m, 1500m three modes of fracture conductivity optimization model, five models are as follows: fracture conductivity is 250mD·m, 300mD·m,
The fracture length of five models is 80 m, the fracture section length is 40 m, each section is 6 clusters, the fracture cluster spacing is 20 m, the fracture single cluster length is 0.6 m, the fracture direction is perpendicular to the wellbore, the stable production time is 3 years, the fracture conductivity model diagram of type I reservoir and type I well is shown in the diagram.

Figure 2. Schematic diagram of class I reservoir conductivity model
The relationship between fracture conductivity and productivity of fractured horizontal wells shows that when the fracture conductivity of fractured horizontal wells in type I reservoir is greater than 400 mD · m, the productivity growth of fractured horizontal wells decreases, so the optimal fracture conductivity is 400 mD · m. When the fracture conductivity of type II reservoir is greater than 300 mD · m, the productivity increase of fractured horizontal well decreases, so the optimal fracture conductivity is 300 mD · m; When the fracture conductivity of type III reservoir is greater than 250 mD·m, the productivity increase of fractured horizontal wells decreases, so the optimal fracture conductivity is 250 mD·m.

4. Fracture length optimization of different reservoirs

The fracture length optimization models of type I reservoir, type II reservoir, and type III reservoir are designed. The horizontal section lengths are 1000 m, 1300 m, and 1500 m, respectively. The numerical models of fracture length of 120 m, 140 m, 160 m, 180 m, and 200 m are established under the conditions of diversion capacity of 400 mD · m and angle between fracture and wellbore of 90 degrees. Among them, the cluster spacing of the five models is 20 m, the cluster width is 0.6 m, the crack length is 40 m, 6 clusters of cracks in each segment, stable production for 3 years, and then compared to optimize the reasonable crack length.
Figure 6. Relationship between different fracture lengths and cumulative gas production in type I reservoir

Figure 7. Relationship between different fracture lengths and cumulative gas production in II reservoir

Figure 8. Relationship between different fracture lengths and cumulative gas production in type III reservoir

It can be seen from the figure that with the increase of fracture length, the productivity increase of fractured horizontal wells gradually decreases, and the reasonable fracture length of type I reservoir is 140 m. The reasonable fracture length of a type II reservoir is 150 m; The reasonable fracture length of a type III reservoir is 170 m.

5. Optimization of fracturing cluster number in different reservoirs

In this study, the optimization models of fracturing cluster numbers for three types of reservoirs, namely, type I reservoir, type II reservoir, and type III reservoir was designed. The lengths of horizontal segments were 1000 m, 1300 m, and 1500 m, respectively. Four models were designed in the study area as follows: single-segment divided into 2 clusters, single segments divided into 3 clusters, single segments divided into 4 clusters, single segments divided into 5 clusters, and single-segment divided into 6 clusters. The fracture length of the five models is 100m, the fracture conductivity is 400mD · m, the fracture length is 80m, the fracture cluster length is 0.6m, the fracture direction is perpendicular to the wellbore, and the stable production time is 3 years. The model results are shown in the diagram.
It can be seen from the diagram of the relationship between the number of fracture clusters and the productivity of fractured horizontal wells that when the number of fracture clusters in type I reservoir is greater than 5 clusters, the productivity increase of fractured horizontal wells begins to decrease, so the optimal number of fracture clusters should be 5 clusters. When the number of fracture clusters in type II reservoir is greater than 3 clusters, the productivity increase of fractured horizontal wells begins to decrease, so the optimal number of fracture clusters should be 3 clusters. When the number of fracture clusters in type III reservoir is greater than 2 clusters, the productivity increase of fractured horizontal wells begins to decrease, so the optimal number of fracture clusters should be 2 clusters.

6. Conclusion
(1) Through the comprehensive analysis of geological parameters and engineering parameters, it is clear that the main controlling factors affecting the fracturing effect in the well area are fracture conductivity, fracture length, and fracture cluster number.

(2) According to the relationship between fracture conductivity and productivity of fractured horizontal wells, it can be seen that when the fracture conductivity of fractured horizontal wells in Class I, II, and III reservoirs is greater than 400 mD·m, 300 mD·m and 250 mD·m, respectively, the productivity increase of fractured horizontal wells decreases, so their optimal fracture conductivity is 400 mD·m, 300 mD·m, and 250 mD·m.

(3) With the increase of fracture length, the productivity increase of fractured horizontal wells gradually decreases, and the reasonable fracture length of type I reservoir is 140 m; The reasonable
fracture length of type II reservoir is 150 m; The reasonable fracture length of type III reservoir is 170 m.

(4) According to the relationship between fracture cluster number and productivity of the fractured horizontal well, the beginning of productivity reduction of the fractured horizontal well is observed, and the optimal fracture cluster number of I, II, and III reservoirs is 5 clusters, 3 clusters, and 2 clusters.

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