Numerical Simulation of Hydraulic Fracturing Effect Based on Abaqus

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Abstract. This study simulates the hydraulic fracturing process based on ABAQUS, and obtains the results of hydraulic fracturing fracture propagation under the influence of multi-parameters. Our research shows that: The effect of reservoir modification increases with the increase of injection rate of fracturing fluid. Under the condition of 8 m³/min or above, the fracture can communicate with the fault zone 100m away from the bottom of the well. Under the condition of 10cP, the effect of fracture propagation in formation is good. Under the condition of 50cP, the effect of fracture propagation in fracture zone is good. Under the condition of 200cP, the effect of crack propagation is poor. When the injection volume of fracturing fluid is between 0 and 1440 m³, the effect of fracture propagation increases gradually. When the injection volume of fracturing fluid is larger than 1440m³, the contribution of continuous injection become weak. The maximum vertical crustal stress results in the fracture extending to the depth. The maximum horizontal crustal stress results in the horizontal propagation of fractured fractures. This study analyzed the influence of formation parameters and hydraulic fracturing parameters on fracture propagation. It also plays an active role in predicting the effect of hydraulic fracturing.

1. Introduction
This paper establishes a fracture type carbonate reservoir formation model, simulates the hydraulic fracturing process, and obtains the formation state after the hydraulic fracturing process based on Abaqus.

2. Background information
There are large reserves of carbonate rocks in a region of Northwest China. Experience shows that the effect of fracturing on stimulation is obvious. The following is a brief introduction of carbonate reservoir and hydraulic fracturing.

2.1. Carbonate Reservoir
Carbonate reservoir is one of many kinds of reservoirs, which is widely distributed in Northwest China. Carbonate reservoirs are often characterized by large reserves and high production. Its reservoir space can generally be divided into three categories (primary pore, fracture and karst cave), so carbonate reservoirs are often divided into dissolution type, pore type and fracture type. Compared with sandstone reservoirs, carbonate reservoirs have many types and regional differences¹. 
2.2. **Hydraulic fracturing**

Hydraulic fracturing is a reservoir modification method that uses surface high-pressure pump to squeeze high viscosity fracturing fluid into reservoir through wellbore\[^2\]. When the injection rate of fracturing fluid exceeds the absorptive capacity of the reservoir, a high pressure will be formed on the bottom of the well. When the pressure exceeds the fracture pressure of the reservoir rock near the bottom of the well, the reservoir will be fractured and fracture will occur. If the fracturing fluid is continuously squeezed into the reservoir, the fracture will continue to expand into the reservoir. In order to keep the fractures open, the sand carrying fluid with proppant (usually quartz sand) is then squeezed into the reservoir. After the sand carrying fluid enters the fracture, on the one hand, the fracture can continue to extend forward, on the other hand, the fractured fracture can be supported so as not to close. Then the replacement fluid is injected, and all the sand-carrying fluid in the wellbore is replaced into the fracture, and the fracture is supported by quartz sand. Finally, the injected high-viscosity fracturing fluid will degrade and drain out of the wellbore automatically, leaving one or more long, wide and high fractures in the reservoir, thus creating a new fluid passage between the reservoir and the wellbore.

3. **Question**

We know little about the effect of hydraulic fracturing on formation. In order to strengthen the prediction of hydraulic fracturing effect, we use numerical simulation method to solve this problem. We established a formation model considering fracture zone and natural fracture. By modifying various parameters, we obtained the influence of several parameters on hydraulic fracturing effect.

4. **Simulation results**

The effect of hydraulic fracturing is related to formation and hydraulic fracturing. We change the viscosity of fracturing fluid, the volume of fracturing fluid and the velocity of injecting fracturing fluid in hydraulic fracturing, and get the formation condition after hydraulic fracturing under these different conditions\[^3\-5\].

| Parameter                        | Parametric values                  |
|----------------------------------|------------------------------------|
| Viscosity of fracturing fluid    | 10cP, 50cP, 100cP                  |
| Volume of fracturing fluid       | 480m³, 960m³, 1440m³, 1920m³, 2400m³, 2880m³ |
| Velocity of fracturing fluid injection | 6m³/min, 8m³/min, 12m³/min       |
| Size of natural cracks           | 0m, 10m, 20m, 50m, 80m             |
| Crustal stress                   | Vertical crustal stress is maximum |
|                                  | Horizontal crustal stress is maximum|

4.1. **Viscosity of fracturing fluid**

The pore pressure between well bottom and the fault zone under each viscosity are shown in the figure below.
Figure 1. Pore pressure with viscosity of 10cP (Left); Pore pressure with viscosity of 50cP (Middle); Pore pressure with viscosity of 200cP (Right)

High pore pressure region of 50cP and 200cP is concentrated in the first fracture zone, and the high pore pressure zone is distributed in the first and second fracture zone at 10cP. When the viscosity of is reduced from 50cP to 10cP, the affected area of the formation increases, but the maximum pore pressure decreases.

4.2. Volume of fracturing fluid

The pore pressure between well bottom and the fault zone under each volume are shown in the figure below.

Figure 2. Pore pressure with volume of 480m$^3$ (Left); Pore pressure with volume of 960m$^3$ (Middle); Pore pressure with volume of 1440m$^3$ (Right)
4.3. Velocity of fracturing fluid injection

The pore pressure between well bottom and the fault zone under each velocity are shown in the figure below.

The higher velocity, the larger the volume of the pore pressure field. The high pore pressure regions are mainly concentrated in the first fracture zone, and as the velocity increases, the volume of high pore pressure velocity increases.

4.4. Crustal stress

The pore pressure, displacement, crack propagation between well bottom and the fault zone under each velocity are shown in the figure below.
When the vertical crustal stress is maximum, the crack shape is higher and shorter in horizontal extension. When the horizontal crustal stress is maximum, the crack shape is lower and longer in horizontal extension.

5. Conclusion

Based on the results of numerical simulation, we conclude the following conclusions:

- The high pore pressure regions are mainly concentrated in the first fracture zone (100m from well bottom), and as the velocity increases, the volume of high pore pressure velocity increases.
- When the viscosity of is reduced from 50cP to 10cP, the affected area of the formation increases, but the maximum pore pressure decreases. 200cP has the worst influence on formation.
- When the injection volume of fracturing fluid is between 0 and 1440m$^3$, the effect of fracture propagation increases gradually. When the injection volume of fracturing fluid is larger than 1440m$^3$, the contribution of continuous injection become weak.
- The maximum vertical crustal stress results in the fracture extending to the depth. The maximum horizontal crustal stress results in the horizontal propagation of fractured fractures.

6. Reference

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