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Under the Non-Uniform Ground Stress Condition for Simulating the Casing Deformation

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Abstract

To the issue about the casing deformation, the paper main study the casing deformation law under the non-uniform ground stress condition, by the ways that the finite element software. The results of the study shows that under the non-uniform ground stress condition, the casing maximum deformation is parallel to the maximum horizontal stress direction. With the increase of the difference between maximum horizontal stress and minimum horizontal stress, the casing deformation increase gradually. And with the elasticity modulus of rock and the Poisson's ratio of formation increase, the maximum deformation is lessen. The elasticity modulus of rock have more effect than the Poisson's ratio of formation. When the elasticity modulus of rock exceed a certain threshold, casing deformation would not be effected by the elasticity modulus of rock.

Key words: Non-uniform ground stress; Casing deformation; The elasticity modulus of rock; The Poisson's ratio of formation

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INTRODUCTION

Nowadays, the number of the casing damage is increase in the each oilfield[1-3], especially with the growing number of injection wells, result of the mudstone absorbed the water, accelerated the casing damage occurs, and the casing damage is usually happen by crush and shear[4-7]. The paper main study the casing damage by crush. And have a numerical simulation study to the casing by the finite element software. At last, we have obtain the regularity of casing deformation influenced by the elasticity modulus of rock, the Poisson's ratio of formation and the difference between maximum horizontal stress and minimum horizontal stress. For prevent the casing damage provide a theoretical basis.

1. THE FINITE ELEMENT MODEL OF CASING UNDER THE NON-UNIFORM GROUND STRESS CONDITION

Using the finite element software to establish the finite element model of layer-casing, and refinement of the wellbore treatment Meshing. As shown in Figure 1, Casing parameter, in the model: Φ139.7 J55; the thickness of casing 7.72 mm, Elastic Modulus 210 GPa, Poisson's ratio 0.3. Formation parameters: The elasticity modulus of rock 27.51 GPa; the Poisson's ratio of formation 0.2; the maximum horizontal stress 24.36 MPa; the minimum horizontal stress 19.67 MPa.

By using the finite element software for the initial parameters, casing deformation of the simulation is studied. The results are shown in Figure 2.

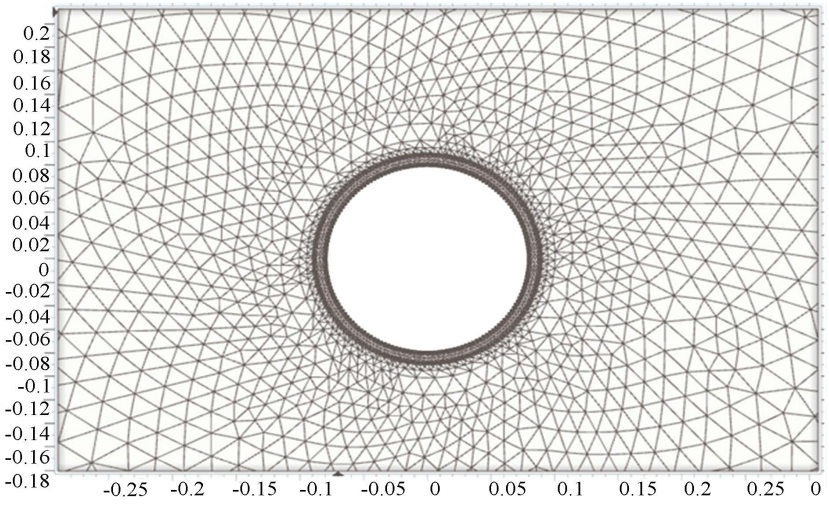

Figure 1
The Finite Element Model of Layer-Casing

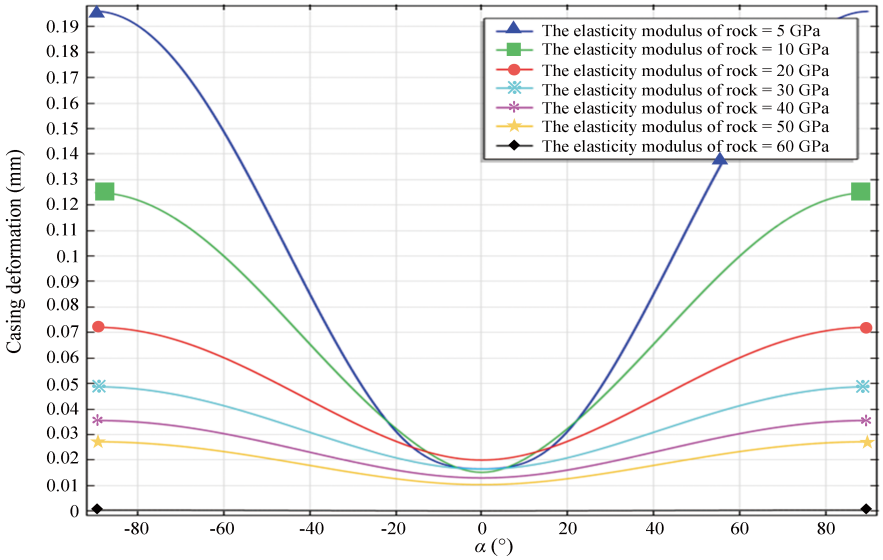

Figure 3
Casing Deformation Under the Different Elasticity Modulus of Rock

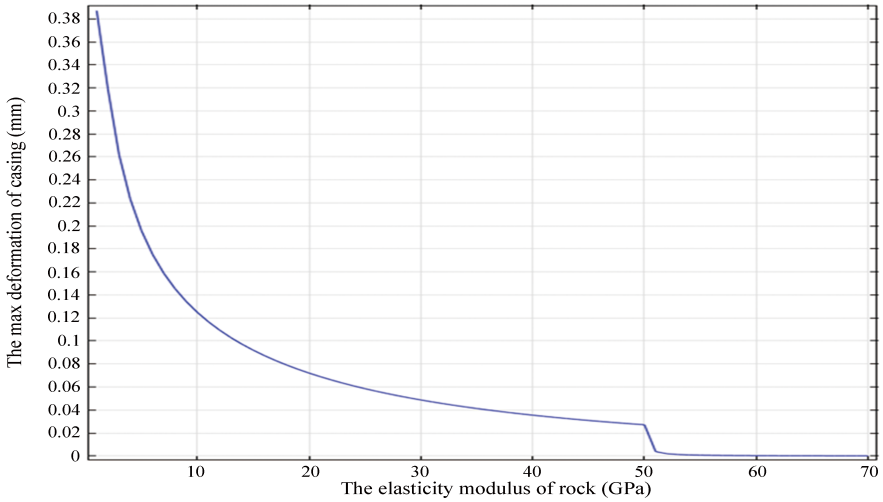

Figure 4
The Casing Maximum Deformation, Under the Condition of the Different Elasticity Modulus of Rock

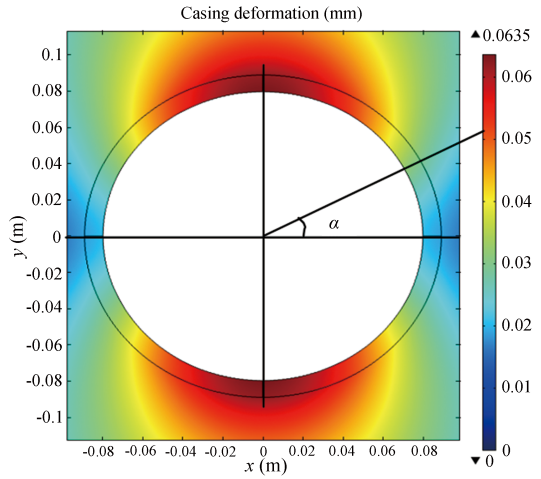

Figure 2
The Contours of Casing Deformation

As can be seen from Figure 2, under the non-uniform ground stress condition, the casing deformation is symmetrical, when the α is between 0° and 180°, with the α increase, casing deformation increases at first, and then lessen. When the α is between 180° and 360°, with the α increase, casing deformation increase at first, and then lessen, deformation is showing the waveform changes with the α increase.

2. NUMERICAL SIMULATION STUDY OF FACTORS WHICH AFFECT THE CASING DEFORMATION

2.1 Casing Deformation Influenced by the Elasticity Modulus of Rock

To simulate the casing deformation, when the elasticity modulus of rock is between 5 GPa and 60 GPa. The simulation results are shown in Figure 3.

From Figure 3, it can be seen that with the elasticity modulus increase, deformation is lessen, and the bigger α, the bigger reduce the amplitude of deformation. When the elasticity modulus of rock varies from 0 to 20 GPa, the volume of casing deformation is lessen, when the elasticity modulus is greater than 20 GPa, the decline of casing deformation is slow, when the elasticity modulus is greater than 50 GPa, and each point on the circumference of the casing, the deformation are the same. For study the change regulation that the maximum deformation of casing with the elasticity modulus of rock, draw the maximum deformation curve of casing under the condition of the different elasticity modulus of rock, as shown in Figure 4.

From Figure 4, it can be seen that with the elasticity modulus of rock increase, the casing maximum deformation is lessen, when the elasticity modulus of rock is little (< 20 GPa), the casing maximum deformation decline is fast, when the elasticity modulus of rock exceed a certain range (> 50 GPa), the casing maximum deformation is no longer affected by the formation of elastic modulus.

2.2 Casing Deformation Influenced by the Poisson's Ratio of Formation

To simulate the casing deformation, when the Poisson Ratio of formation is between 0.1 and 0.4. The simulation results are shown in Figure 5.

As can be seen from Figure 5, with the increase of the Poisson's ratio, casing deformation is lessen, and the point of larger angle α, the fast decline of casing deformation. However, compared with the elasticity modulus of rock, Poisson's ratio effect on the casing deformation is weaker. For study the change regulation that the maximum deformation of casing with the Poisson's ratio of formation, draw the maximum deformation curve of casing under the condition of the different Poisson's ratio of formation, as shown in Figure 6.

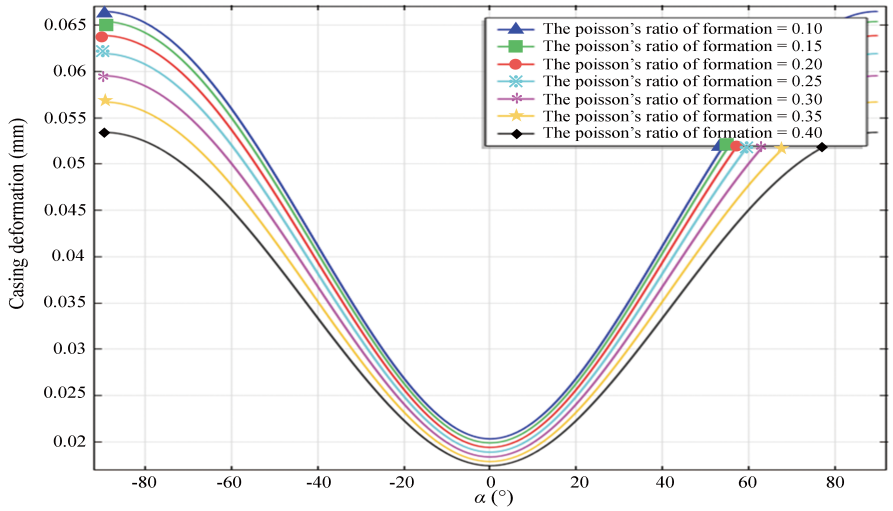

Figure 5
Casing Deformation Influenced by the Different Poisson's Ratio of Formation

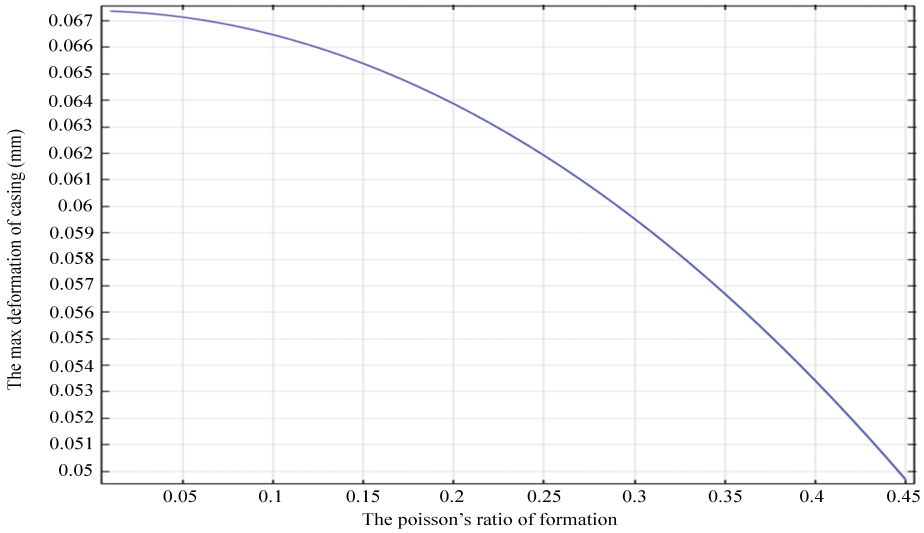

Figure 6
The Casing Maximum Deformation, Under the Different Poisson's Ratio of Formation

As can be seen from Figure 6, with the increase of the Poisson's ratio of formation, casing deformation is lessen, when the Poisson's ratio of formation is little (< 0.25), the decline of casing maximum deformation is slow, when the Poisson's ratio of formation exceed a certain range (> 0.25), the decline of casing maximum deformation is fast.

2.3 Casing Deformation Influenced by the Difference Between Maximum Horizontal Stress and Minimum Horizontal Stress

To simulate the casing deformation, under the condition of the difference between maximum horizontal stress and minimum horizontal stress, the simulation results shown in Figure 7.

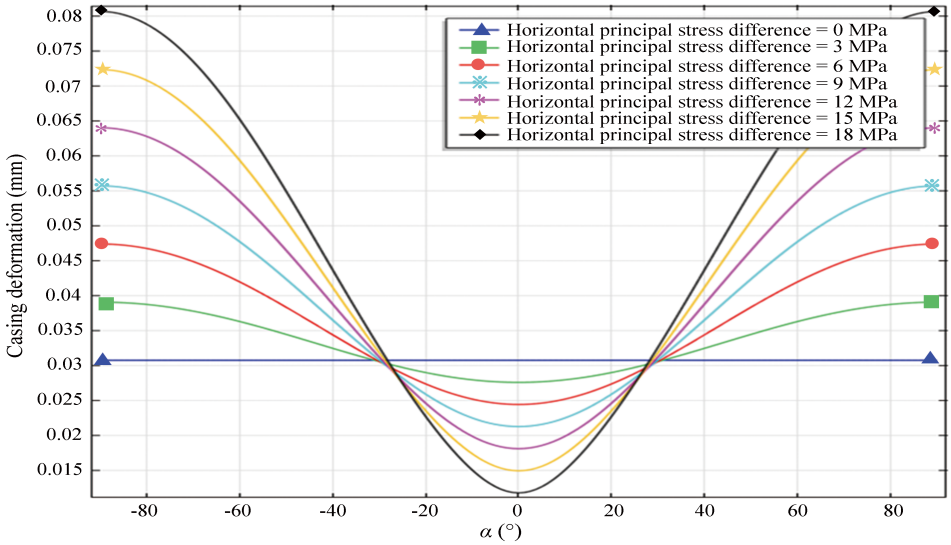

Figure 7
Casing Deformation Influenced by the Difference Between Maximum Horizontal Stress and Minimum Horizontal Stress

As can be seen from Figure 7, when the difference between maximum horizontal stress and minimum horizontal stress is 0, the deformation of each point is the same. The point near the $\alpha = 30°$ is almost not changed. The point of $30° < \alpha < 90°$, with the increase of the difference between maximum horizontal stress and minimum horizontal stress, the casing deformation increase gradually. The point of $0° < \alpha < 30°$, with the increase of the difference between maximum horizontal stress and minimum horizontal stress, the casing deformation decrease gradually. For study the change regulation that the maximum deformation of casing with the difference between maximum horizontal stress and minimum horizontal stress, draw the maximum deformation curve of casing under the condition of the different between maximum horizontal stress and minimum horizontal stress. As shown in Figure 8.

As can be seen from Figure 8, with the increase of the different between maximum horizontal stress and minimum horizontal stress, the casing maximum deformation increases linearly. So, for the formations which have larger initial horizontal stress, we should be taken care of the occurrence of casing damage.

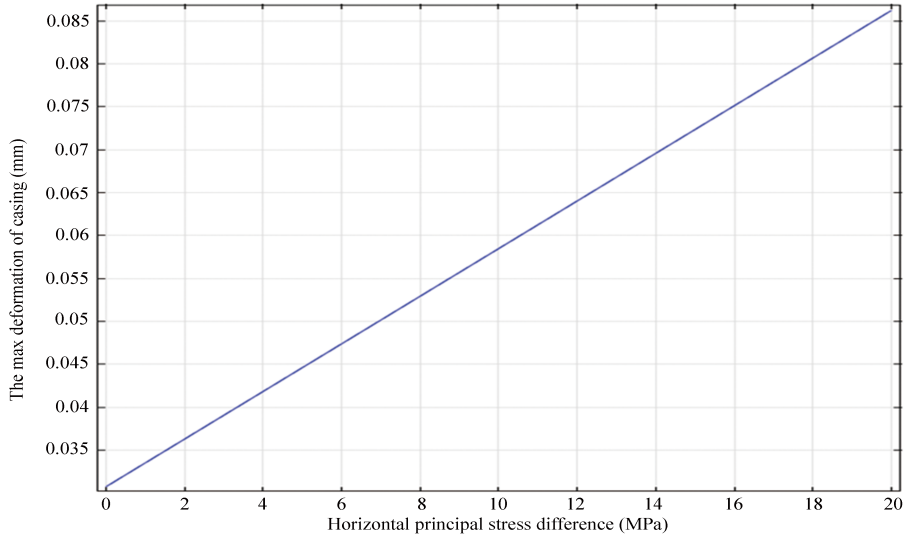

Figure 8
The Casing Maximum Deformation, Under the Different Between Maximum Horizontal Stress and Minimum Horizontal Stress

CONCLUSION

Casing deformation is symmetrical, the casing maximum deformation is parallel to the maximum horizontal stress direction. In the course of field operations, it is the most likely to occur damage.

The larger elastic modulus and Poisson's ratio formation, casing deformation is small, casing is not easy to be damaged; But if the different between maximum horizontal stress and minimum horizontal stress is larger, casing deformation is bigger, and the casing is easy to be damaged.

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