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Finite Element Simulation of Casing Shearing Impairment in Different Cementing Method

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Abstract

Casing impairment in Sazhong block, Daqing oilfield is serious recently. Most of casing failure type is casing shear slip in Nen'er marker layer where a part of well did not cemented. It has a great influence on stress and deformation in the progress of casing shear if the marker bed cemented or not. This paper considered the casing and rock mechanics characteristic after yield, established finite element models to analyze the casing reaction force in the progress. Result shows that stress and deformation of casing is lager than that of side wall rock in two models. In the uncemented well, there is a space between the casing and wellbore. The space can be regard as a buffer room for the formation slip. Uncemented condition is conducive to prevent and repair casing shear failure in marker bed.

Key words: Finite element; Casing impairment; Shearing failure; Daqing oilfield; Maker layer

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INTRODUCTION

The situation of casing impairment in Sazhong block of Daqing oilfield is very serious, especially after 2005 when the impairment rate rising faster. Most of the casing impairment layer is the upper layer of oil formation, concentrating in Nen'er marker formation which has about only 10 m thick. About 40% casing damage is impairment at Nen'er marker formation which contains lots of fossil and weak horizon interfaces[1-4]. Many underground works proved that the damage pattern was shearing slip failure[5,6]. The reason for shearing casing failure in marker formation is the weak interface slipped by formation pressure changes[7,8].

When the horizon weak interface in marker formation slipped, the upper and lower layer moved relatively by the force of gravity and original ground stress. A part of well cemented at Nen'er marker formation shown as Figure 1(a) while others did not cemented shown as Figure 1(b).

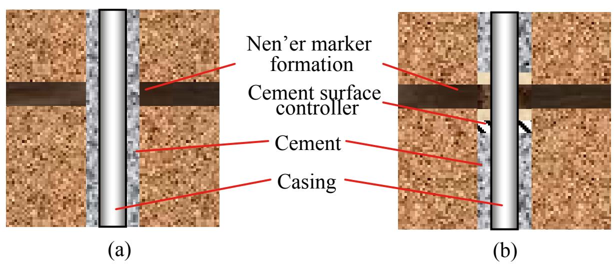

Figure 1
(a) Nen'er Marker Formation Cemented Well, (b) Nen'er Marker Formation Uncemented Well

For the cemented well, the shearing force delivered from formation to cement and finally to casing when formation shear occurs. This condition of casing shear was studied by Huang Xiaolan and Jin Chunyu and so forth[9,10]. For the uncemented well, the shearing force delivered from wellbore to casing when the shearing moment equals the distance between casing and wellbore in the progress of casing shear failure.

There are a few studies on the condition of the uncemented well shearing. This paper takes casing elastoplasticity deformation into consideration, built a cemented well model and an uncemented well model, calculate the counterforce of casing when shearing casing by using finite element calculation.

1. FINITE ELEMENT GEOMETRIC MODEL

Analysis shows that the stress concentration near wellbore decrease under 5% where the distance 5 times farther than wellbore radius[11]. So a 1 m long, 1 m wide formation which has a 0.1 m wellbore in the center was built. A casing with 139.7 mm outside diameter and 1 m height was inside the wellbore. Assuming the weak interface of marker formation was broken, built two layers of formation with 0.5 m height.

For the cemented well model, the casing is in the middle of the wellbore, the cement is in the annular space of the casing and wellbore. For the uncemented well model, the initial situation started from the casing shearing point to increase the calculation speed. The left of casing connecting with the upper formation while the right of casing connecting with the lower formation.

2. BOUNDARY SYSTEM

In the two models, shearing casing impairment was caused by upper and lower formation shear slip. To minimize the boundary effect, the prescribed displacement of *yz* direction side formation in upper layer was set equal to formation slip displacement. The prescribed displacement of normal direction for other formation side was set to 0. For the uncemented well model, left of casing and upper formation layer was defined as the contact surface, and the same to the right of casing.

3. MATERIAL MECHANICS PARAMETER AND MESH DIVISION

In the practical oil production, the casing does not represent failure if the plastic deformation is small. As long as the casing can maintain its integrity and the degree of deformation does not affect the operation and construction, the casing has not yet meaning failure. There is great deformation in the analyzed casing impairment, so the casing and rock mechanics characteristic after yield was considered. According to harden elastoplastic model[12], the constitutive equation of alloy steel or other hardening material can be simplified as a polygonal line. Casing constitutive equation is assumed as

$$\sigma = \begin{cases} \boldsymbol{E}\varepsilon & (\varepsilon \le \varepsilon_s) \\ \sigma_s + \boldsymbol{E_l}(\varepsilon - \varepsilon_s) & (\varepsilon > \varepsilon_s) \end{cases},$$

where *s* is stress in casing, s_s is casing stress intensity, *E* is Young's modulus and E_l is harden stage modulus. Von mises stress was use to discretion casing yield.

$$\sigma_s = \frac{1}{\sqrt{2}}\sqrt{(\sigma_x-\sigma_y)^2+(\sigma_y-\sigma_z)^2+(\sigma_z-\sigma_x)^2+6(\tau_{xy}^2+\tau_{yz}^2+\tau_{zx}^2)}\ .$$

P110 steel grade casing with the initial yield stress 758 MPa is often used in Daqing oilfield. Casing Young's modulus is 208 GPa, harden stage modulus is 710.6 GPa and poisson ratio is 0.28. Nen'er marker formation is oil shale, average Young's modulus is 20 GPa, poisson ratio is 0.25, angle of internal friction is about 25 degrees and the uniaxial compressive strength is about 30 MPa. In the Young's modulus of the cement in the cemented well model is 20 GPa, poisson ratio is 0.23 and the uniaxial compressive strength is 40 MPa.

The stress is concentrated in casing especially near the slip surface, so the casing and shearing surface were subdivided. The mesh of the two models is shown in Figure 2.

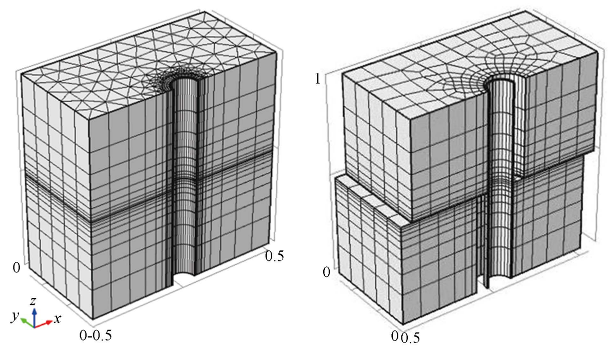

Figure 2
The Result of Finite Element Division

4. FINITE ELEMENT SIMULATIONS

The formation slip displacement was set from 0 mm to 50 mm. Calculation shows that the shearing stress concentrated at casing especially near the slip surface of the two models.

The casing deform concentration in the cemented well model is greater than that in the uncemented well model. About 0.3 m height range casing is yield in the cemented well model while about 0.5 m height in cemented well model. Only a small area near the slip surface of wellbore broken in the two models although casing strength is much harder than wellbore rock strength. The Von Mises stress is shown in Figure 3.

When the casing has shearing failure, the casing and cement will provide reaction force to prevent the formation slip. Figure 4 shows the reaction force with two types of cemented well in the casing shearing process.

The two models in the casing shear process, casing and cement enter plastic period when the formation have a little slip. The reaction force will precipitous decline with the slip distant increase. Under the cement effect, the cemented well model can supply more reaction force in the formation slip process.

The reaction force is different when the casing thickness changes in two models. Casing with 139.7 mm outside diameter, which type has casing thickness standard has 6.20 mm, 7.72 mm and 10.54 mm, are often used. The reaction force in the progress of casing slip failure in two models is shown as Figure 5.

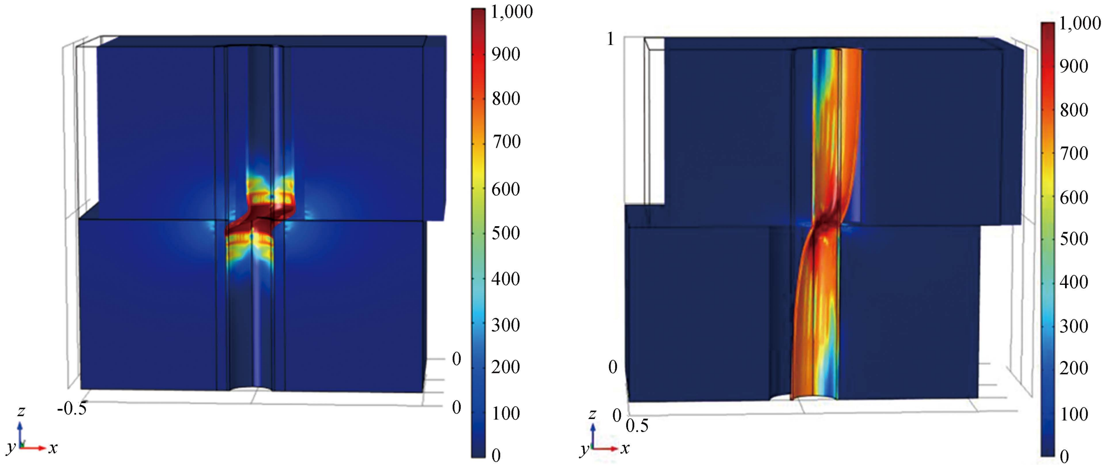

Figure 3
The Von Mises Stress in Two Models

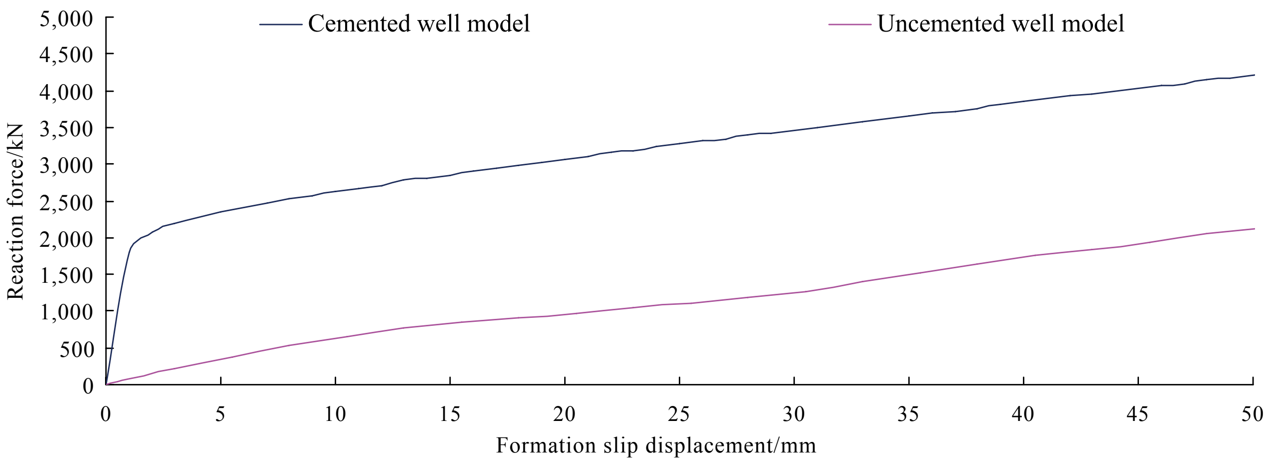

Figure 4
The Reaction Force of Casing in Different Cement Type

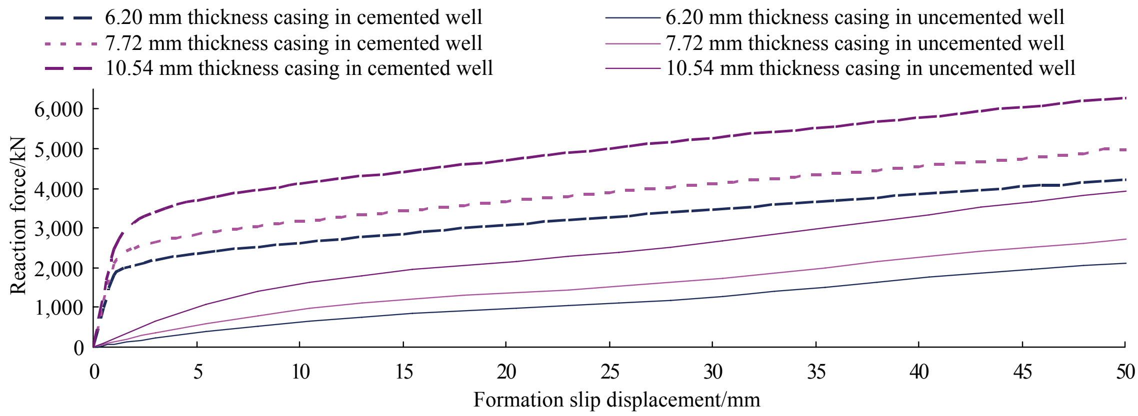

Figure 5
The Reaction Force of Casing in Different Thicknesses

Result shows that the reaction forces increase when casing wall thicker. Casing with wall thickness 6.20 mm yield when slip displacement is 46.2 mm in uncemented well model while 10.54 mm thickness casing yield when displacement equals 40.7 mm. When slip displacement reach 50 mm the reaction forces of 6.20 mm thickness casing is 4,205 kN and 2,137 kN in Cemented and Uncemented well model respectively while the reaction forces increase to 6,280 kN and 3,964 kN when use 10.56 mm thickness casing. It means that thicker casing can supply more reaction force but easier to failure.

But, the reaction force from the casing and cement is too small to stop the formation slip. The formation need to overcome the force of friction. For example Nen'er marker layer depth is 750 m, overburden density is 2,000 kg/m^3, single well average area is 1,500 m^2 per well, rock friction factor is 0.2, we can gain single well average area formation slip friction resistance is 4.41×10^6 kN, it is far more than the reaction force.

After the casing shear failure, the formation will not continual slipping. With the formation slip, the force of formation slip will be released until it is not enough to make the formation slip. In the uncemented well, there is a space between the casing and wellbore. When the formation slip distant excess the space, the casing will begin shear failure. But in the same distant, the cemented well will deform serious. So Nen'er marker layer uncemented well is advantage of preventive shear casing failure.

CONCLUSION

(a) The reaction forces increase when casing wall thicker in the progress of casing slip failure. Thicker casing can supply more reaction force but easier to failure.

(b) In the model of Nen'er marker layer cemented well, the casing and cement can supply more reaction force than that in the uncemented well in the formation slip process, but it is too small to stop the formation slip. In the uncemented well, there is a space between the casing and wellbore. The space can be regard as a buffer room for the formation slip. Therefore, Nen'er marker layer uncemented well is advantage of preventive shear casing failure.

REFERENCES

[1] Wang, F., Wu, Z. H., & Li, B. X. (2005). Study on the Casing Damage in Western Bei2 Area of Saertu oilfield. *Petroleum Geology & Oilfield Development in Daqing*, *24*(1), 74-79.

[2] Liu, H., Liu, J. D., & Zhuo, S. G. (2006). Geological factors for controlling damage of batch casing in the member II of Nenjiang formation in Daqing oilfield. *Acta Petrolei Sinica*, *27*(5), 135-138.

[3] Liu, H., Zhuo, S. G., & Gao, H. M. (2006). A new mechanism of the local regional casing impairment of the index bed of member of the Nenjiang formation and its petrology and mineralogy in the Daqing oilfield. *Geological Review*, (4), 532-538.

[4] Sun, M. X., Cheng, Y. F., & Jia, J. H. (2012). Casing failure mechanism and numerical calculation for low permeability and complex fault block reservoirs. *Fault Block Oil & Gas Field*, (6), 788-791.

[5] Wang, Z. Y., Ma, W. Z., & Zhou, Z. B. (2007). Study and application of casing stress measuring tool. *Well Logging Technology*, *32*(2), 163-165.

[6] Yi, J., Li, Z., & Zhang, L. (2012). Numerical simulation study on disturbance of stress and strain induced by mudstone soaking during development of oilfield. *Petroleum Geology and Recovery Efficiency*, *19*(6), 95-99.

[7] Li, L. Q., Kang, H. Q., & Jiang, G. P. (2007). New knowledge of casing damage genetic mechanism and integrated control technique. *Petroleum Geology & Oilfield Development in Daqing*, (1), 83-87.

[8] Wu, E. C., & Yan, T. (2007). Analysis of casing damage mechanism in fossil formation in N2 index bed of Daqing oilfield . *Journal of Northeast Petroleum University*, (2), 38-41.

[9] Huang, X. L., Liu, J. J., & Yang, C. H. (2009). Mechanism analysis and numerical simulation of casing's shear failure in water injection oilfield. *Journal of Wuhan Polytechnic University*, *28*(3), 94-97.

[10] Jin, C. Y., Ai, C., & Yu, H. J. (2011). Study on collapsing strength caused by easing deformation. *Petroleum Geology and Recovery Effieieney*, *18*(5), 104-107.

[11] Zhang, X. Y. (2001). Analysis of some problems in casing calculation by finite element method. *Natural Gas Industry*, (1), 62-65.

[12] Huang, M. L., Liu, S. Q., & Zhang, X. H. (2005). Mechanical plastic technology on damage and deform action casing. *Oil Drilling & Production Technology*, (S1), 82-84.

