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Research article

Sensitivity Analysis and determination of the most important affecting parameters in the stability of oil wellbores based on numerical modeling in Phase2

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Keywords

Sensitivity Analysis
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English Extended Abstract

Summary

In this research, the importance of the parameters affecting the oil wellbore stability has been investigated. This study has been performed by the finite element method and modeling in the Phase 2 software. "Maximum total displacement" is considered as the representative of wellbore stability. The impact of each parameter on the wellbore stability was investigated by changing the values of the parameters. Finally, pore pressure and drilling mud pressure were recognized as the most important parameters affecting the wellbore stability.

Introduction

Excavation of oil wells causes stress concentration in the wellbores' wall by removing the in-situ material from the well. Wellbore wall failures force very high non-productive costs on the oil industry. As a result, performing a suitable stability analysis for the oil well is necessary, for which the parameters affecting the stability of the oil well should be identified. Some many factors and parameters affect the rock mass stability but the role of all these parameters is not the same. One has to identify the order of importance of all the parameters.

Some parameters are called controllable parameters like pore pressure their values can be increased or decreased by the driller but others like pore pressure, friction angle, and cohesion coefficient are called uncontrollable parameters and the driller cannot increase or decrease their values, but the accuracy in the measurement of them is important that controllable parameters can be adjusted based on them. Therefore, because their measurement and adjustment have a direct relationship with the stability of the wellbore and achieving the desired result, their level of accuracy should be proportional to their importance. More cost for more important parameters is reasonable and leads to better results.

Methodology and Approaches

Nowadays, several numerical methods are available for the stability analysis of oil wells. Among them, the most commonly used are the finite element method (FEM), boundary element method (BEM), and discrete element method (DEM) and hybrid methods. In this research finite element models were made by Phase2 software and then a dimensionless sensitivity analysis was performed using the results of FEM models. In this research effect of seven parameters (including Young's modulus, cohesion coefficient, internal friction angle, drilling mud pressure, Poisson ratio, pore pressure, and horizontal lateral stresses ratio) on the stability of wellbore is studied. In the dimensionless sensitivity analysis given a system whose character, P,

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is governed mainly by n factors of $\alpha = \{\alpha_1, \alpha_2, \dots, \alpha_n\}$ and P is a function of α and Then a function is defined based on the relation between P and α_k where $1 \leq k \leq n$ and finally determines a factor called "sensitivity factor". The sensitivity factor indicated the relation of relative variation in P (Maximum total displacement in this study) to the relative error of α_n (the seven parameters mentioned above in this study). The sensitivity factor of each parameter shows the importance of that parameter.

To analyze the sensitivity of each parameter, the parameter varies within its variation range but the other parameters remain constant, and other models of the studied parameter are made. The models are solved and the maximum total displacement of the wellbore wall is considered as a parameter representing the wellbore stability. Then the relation between the studied parameter and maximum total displacement (wellbore stability) is expressed by a function. Then the sensitivity factor of the studied parameter is determined. Then the process will be repeated for the other parameters. Then the effect of each parameter on the stability of the wellbore was investigated by analyzing the diagrams and the parameters were arranged from highest to lowest by comparing the sensitivity factors. In this research, a plan view of a wellbore was investigated. The wellbore is vertical and has a circular section with a diameter of 10 cm. Firstly, an initial pore pressure of 21 MPa is given to the basic model and its loading conditions are as shown in Fig and the basic values of parameters and the variety range of them are shown in the Table 1.

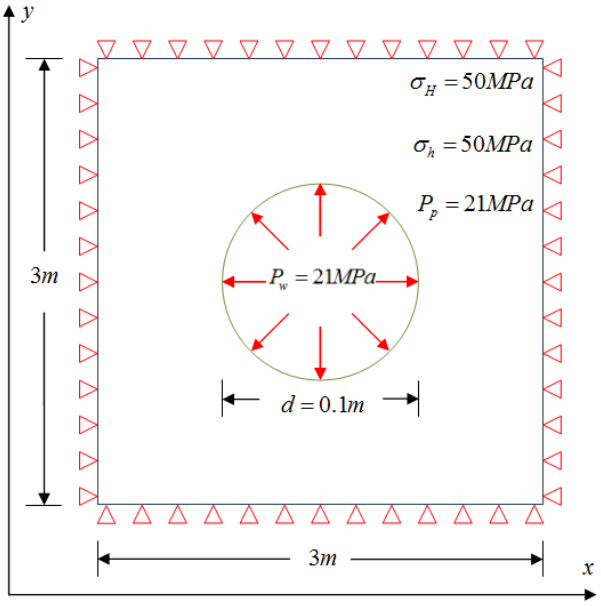

Fig. 1 Plan view and loading conditions of the model

Table 1. Maximum, minimum, and basic values of the investigated parameters

Parameter	E(MPa)	ν	C(MPa)	φ(deg)	P_w(MPa)	P_p(MPa)	K
Basic Value	15	0.25	2	14	14	21	1
Minimum value	5.00	0.11	0.67	4.67	11.67	7.00	0.33
Maximum value	45.00	0.35	6.00	42.00	49.00	0.28	3.00

Results and Conclusions

The final result of this research is rating the parameters' stability based on their importance of in the wellbore stability. This importance was expressed by the sensitivity factor. Then the parameters were rated based on their sensitivity factors as summarized in Table 2. Sensitivity factors from highest to lowest are as follows: pore pressure, drilling mud pressure, horizontal lateral stress ratio, internal friction angle, cohesion

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coefficient, Young's modulus, and Poisson's ratio.

Table 2. The sensitivity factors of investigated parameters

Parameter	*E(MPa)*	ν	*C(MPa)*	$\varphi(deg)$	$P_w(MPa)$	$P_p(MPa)$	*K*
Basic Value	*1.0000*	*0.2867*	*1.6560*	*2.3660*	*6.5040*	*7.2452*	*1.7301*

The results show that the pore pressure is the most important parameter affecting the wellbore stability and its sensitivity factor is 7.25. This means that a variation of 15% in P_p, leads to a relative variation in Maximum total displacement of $7.2452 \times 15\% = 108.68\%$. The sensitivity of two parameters, pore pressure and drilling mud pressure, is significantly higher than the other parameters, and on average, it is about 4.5 times more important than other parameters.

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