Petroleum and Chemical Engineering Department-College of Engineering-Sultan Qaboos University

Probabilistic Approach in Wellbore Stability

Mahmood Rashid Al-Khayari

Abstract

In oil industry, the production of hydrocarbon (oil and gas) requires many operations that should be done efficiently in order to cut off the costs. Wellbore instability is the most costly problem that a well drilling operation may encounter. One reason for wellbore failure can be related to ignoring rock mechanics effects. A solution to overcome this problem is to adopt in-situ stresses in conjunction with a failure criterion to end up with a deterministic model that calculates collapse pressure. However, the uncertainly in input parameters can make this model misleading and useless. Therefore, it is important to develop a probabilistic stability model to run risk analysis covering all possible scenarios.

In this thesis, a new probabilistic wellbore stability model is developed to predict the critical drilling fluid pressure before the onset of wellbore collapse. In this model, the linear elastic constitutive model in conjunction with Mogi-Coulomb failure criterion have been used. An Excel sheet has been developed to find critical mud pressures for any input parameters. The model runs Monte-Carlo Simulation to capture the effects of uncertainty in in-situ stresses and rock properties. It also accounts for the effects of drilling trajectories. Risk analysis can be done based on the output of the developed model to improve risk management of wellbore instability.

The developed model was applied to different in-situ stress regimes: normal faulting, strike slip and reverse faulting. For each stress regime, simulations were run for different scenarios: changing all parameters simultaneously, changing one parameter while keeping the rest of parameters at fixed values, fixing all parameters except rock properties parameters, fixing all parameters except in-situ stress parameters, and fixing all parameters except well trajectories.

Sensitivity analysis was applied to all carried out simulations to find out which parameter has the major impact on collapse pressures. The results show that well trajectories have the biggest impact factor in wellbore instability in almost all of in-situ stress regimes. Rock properties come in the second place.

The developed model improves risk management of wellbore stability. It helps petroleum engineers to forecast collapse pressure, and then make right decisions on selecting drilling mud pressure. It is also a helpful tool for field planners in cost estimation during fields development.