Introduction

Stability problems in drilling wells cause additional and unnecessary costs and time. It is even dangerous for people's lives due to the lack of knowledge in rocks' properties. Today's well construction projects are so challenging like offshore projects in Canada, Newfoundland, Hibernia, deep-water wells in the Gulf of Mexico in a harsher environment, high-pressure and high-temperature wells in Norway. As a result, companies could not ignore these functional problems (Last et al., 2007; Udegbunam et al., 2014; Zhang et al., 2010).

Geoscience engineers face some difficulties in the process of estimating geomechanical parameters. The main one is the uncertainties — this unpredictability caused by two reasons. One of them is a lack of data and information on parameters and models. The other one is that the data which are obtained from logs are not precise. In order to cover these uncertainties, researchers and scientists with the help of engineers develop many mathematical base methods. Probabilistic methods are so common to quantify uncertainties. The frequentist approach is a probabilistic method using to treat uncertainty in rock mechanics (Contreras et al., 2018; Miranda et al., 2009; Wantawin, 2016).

This is accessible for uncertainty characterization by using simulating of the realizations, which were sampled to their correct probability. So many methods have been proposed for quantifying uncertainty, and some of them were used in petroleum industries like Ensemble Kalman Filter, Stochastic optimizer, Randomized Maximum Likelihood, etc. Markov Chain Monte Carlo (MCMC) is a methodology for sampling from probability distributions and has been used for quantifying uncertainty in reservoir simulations (Oliver et al., 2008).

The purpose of this article is first to calculate geomechanical parameters by building 1D mechanical earth modeling (MEM). For the next stage, quantifying uncertainties of geomechanical parameters with Markov Chain Monte Carlo. This method is more accurate than the methods like Monte Carlo that the previous researchers have been applied. At the end, we designed a mud window by the Mohr-Coulomb failure criterion.

Building MEM

Wellbore stability is so crucial in drilling and production operations, so to prevent stabilities problems, we should consider two wellbore failure mechanisms, which are shear and tensile that related to fracture and borehole collapse. To measure fracture and borehole collapse pressure, at first, we should build Mechanical Earth Model (Afsari et al., 2009; Bradley, 2010).

To build MEM such information like logs, drilling data, seismic data, leak off test data are required. Mechanical earth modeling consists of geomechanical parameters such as Poisson ratio, Young Modulus, friction angle, in-situ stress, rock density, etc. (Afsari et al., 2009).

The available data are gathered from one of the southern fields of Iran.

Uncertainty quantifications

By simulating the future performance of many realizations that have been sampled according to their probability of being correct, it is possible to characterize the uncertainty. For characterizing the uncertainties, it is possible to generate realizations by simulating the performance using the probability that has made sampled from.

Markov Chain Monte Carlo

Markov Chain Monte Carlo (MCMC) is a good method especially when it is needed to generate a large number of realizations. MCMC is a method that is based on the Markov chain for sampling from probability distributions, and Monte Carlo is used for random sampling in the range of Markov chain
to control it. It is memoryless and ergodic. Markov chain generates realizations based on relative probabilities. One of the main benefits of MCMC is that it does not need to know the normalizing constant which is required to make a proper probability density function. Finding the normalizing constant is hard (Oliver et al., 2008).

**Mud window**

To perform wellbore stability analysis, calculating formation strength and in-situ stress are needed and then to determine optimum mud pressure use the failure criterion. Failure criteria apply to predict borehole collapse and induced fracture. Mohr-Coulomb is one of the most important and common failure criteria. It is simple and has a good result. Scientists and researchers and even engineers in industries use this failure criterion, although they know that this criterion neglects the intermediate stress (Maleki et al., 2014; McLean and Addis, 2007).

**Results**

After defining the MEM, the MCMC is used to quantify the uncertainties. We just represent Poisson ratio, collapse pressure and fracture pressure because of their importance in our works. We represent Markov chain Monte Carlo sampling method results for the collapse pressure and fracture pressure in PDF & CDF & histogram figures. Collapse pressure are represented by CDF, PDF & histogram in Figure.1 & 2

![Figure 1 PDF & CDF & ECDF of collapse pressure](image1)

![Figure 2. collapse pressure histogram from MCMC sampling method](image2)
Fracture pressure are represented by CDF, PDF & histogram in Figure 3 & 4.

**Figure 3** PDF & CDF & ECDF of fracture pressure

**Figure 4** Fracture pressure histogram from MCMC sampling method

Mud window could be seen in the Figure 5. This is designed by the posterior data that were obtained by the MCMC.
Most of the approaches for uncertainty treatment are used to deal with uncertainty based on classical statistics. In order to use the conceptual implications of the models and parameters in the conventional approach, the collected data are the only available elements. In the frequentist approach of statistical analysis, data are mentioned to be a set of random variables to estimate the value of parameters. Probabilistic methods are used for treating uncertainties in many fields of research. In a conventional way, the frequentist approach is used. This is based on the interpretation of probability as frequencies of outcomes of random trials repeated many times for statistical analysis. So, the sampling methods are used in these kinds of problems.

**Conclusion**

A novel methodology is developed to design a reliable safe mud window based on most updated geometrical uncertainty distribution. The developed approach allows to estimate the uncertainty ranges for geometrical parameters and their dependent parameters such as collapse pressure and fracture pressure. A trustable mud window design based on posterior probability reduces the risks of wellbore stability problems and less kick.

**References**


