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The Use of a Fully Coupled Geomechanics-Reservoir Simulator To Evaluate the Feasibility of a Cavity Completion

E. Zuluaga and J.H. Schmidt, Chevron ETC, and R.H. Dean, Simwulf Systems

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Abstract

Cavity completions have been widely used to increase productivity from non-conventional sources such as coalbed methane reservoirs and “heavy” oil from weakly consolidated formations. In the 1990s, the technique was applied to conventional wells where massive sand production was allowed with the objective of creating a cavity. The benefits expected from a cavity completion are four-fold: 1) increase in PI by reducing skin, 2) increase in effective wellbore radius 3) creation of an enhanced permeability (dilatant) zone near the wellbore, and 4) decrease in pressure drop near the wellbore to values below the critical threshold for sanding.

Even though there are analytical tools available for predicting the initiation of sanding for simple well configurations, there are very few models that are capable of predicting cavity stability or cavity growth for general field applications. This paper introduces results from a fully-coupled geomechanical/reservoir simulator, GMRS®, which predicts cavity geometry evolution, sanding rates, cavity stability/instability, and production enhancement because of the creation of a cavity.

In this study, GMRS® is used to investigate the feasibility of a cavity completion in a well located offshore West Africa. This well started producing moderate amounts of sand in 1993. GMRS® is history matched with historical production data prior to sand predictions, and is used to investigate cavity initiation and growth for the well. An axisymmetric model is used with the reservoir treated as a poroelastic-poroplastic material with hardening. Porous flow is modeled as a black-oil two phase (oil and water) flow model. For the well investigated, sensitivity studies with varying formation properties predict that sand production and cavity generation will be unstable.

Introduction

Different tools for prediction of sand production have been discussed in the literature. The range includes analog studies, log-based predictions, core studies and integrated core/log /failure simulation studies (Morita, N., 1994, Bennett et al., 2000). Most commonly, the predictions are performed with analytical and empirical tools that consider the state of stresses in the formation to determine critical drawdowns at which sand production is expected (Palmer et al., 2005; Hettema et al., 2006). It has been recognized that high production rates, increasing effective stress with depletion, and water breakthrough contribute to sand production; however, these pseudo-static tools do not consider the effect of flow mechanics when making sand initiation predictions. Yale (2002) showed that a reservoir that undergoes plastic deformation requires modeling that fully couples fluid flow-fluid pressure-reservoir stress-rock deformation.

With the advent of fully coupled geomechanics/reservoir simulations these limitations of static sand prediction models have been overcome. Coupled geomechanics/reservoir simulators allow evaluations of geometry, stability and expected changes in oil rates as sand is produced.

Cavity completions have been used throughout the oil industry for several decades. It was initially used in heavy oil production and coalbed methane reservoirs and later extended to conventional wells. The concept allows the co-production of sand and hydrocarbons with the benefits of reducing the near wellbore skin, increasing the permeability of the near wellbore region and boosting oil and gas production rates. In the last decade, cavity completions have proven to significantly impact productivity in conventional wells (Palmer et al., 2000; Palmer et al., 2005). Cavity completions are a low completion cost procedure since they do not require expensive sand-control devices. However, the trade-off is the increased risk of allowing free production of sand which can compromise the integrity of the well, surface facilities and potentially increase costs associated with workover operations. Several guidelines have been established for selection of a candidate well suitable for a cavity completion. A successful cavity completion entails the formation of a cavity or enhanced permeability zone that stabilizes with time. Under these conditions, sand production should stop once the pressure drawdown falls below the threshold for sand production. However, only the simulator stability of a fully-coupled flow mechanics with stress state can provide answers