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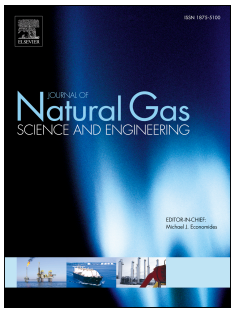

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Modeling of Near-Wellbore Fracturing for Wellbore Strengthening

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Abstract

While drilling through depleted or partially depleted reservoirs, one may encounter a series of problems (e.g., lost circulation, non-productive time, etc.) due to narrow mud weight window (MWW). Fracture-based strengthening techniques used in the industry effectively increase fracture reopening pressure (FROP) and ultimately reduce the cost of associated problems. However, traditional analytical and numerical studies using these techniques do not consider the time effect and usually ignore the fluid dynamics. Thus, these deficiencies may result in inaccurate wellbore strengthening operations if no proper fracture diagnostic techniques are available to acquire the real-time fracture geometry. In this paper, a quasi-static, dislocation-based fracture model is extended using fluid mass conservation with leak-off. A fixed dimensionless fracture coordinate system is employed and a numerical simulation procedure is developed. The model is capable of predicting real-time fracture geometry (both fracture width and length) from given wellbore conditions. Hence, it could provide optimal particle size distribution (PSD) selection for wellbore strengthening applications. Two case studies are performed and results reveal different fluid controlling mechanisms during the fracture propagation, which are fluid storage in fractures and fluid leak-off to surrounding formation. Drilling through low permeability reservoirs (e.g., tight gas reservoirs or shale reservoirs) is different from drilling in conventional reservoirs because fast propagation of induced fractures may interact with natural fractures and result in severe lost circulation. This model is of critical importance in designing wellbore strengthening operations during drilling.

1. Introduction

Pore pressure reduction due to oil production in depleted reservoirs may cause subsidence (Geertsma 1973; Zhang et al. 2016b) and the reduction of in-situ stresses, which is known as stress path (Addis 1997; Shahri and Miska 2013). Correspondingly, the fracture gradient, which is the upper limit of MWW, is decreased to narrower MWW (Aadnoy 1991; Shahri et al. 2013). Drilling becomes impossible through these sections and severe lost circulation may occur (Chen et al. 2014; Chen et al. 2015). The estimated worldwide cost for lost circulation is about $2-4 billion per year (Growcock 2010). Different wellbore strengthening techniques, which include fracture-based and non-fracture based methods, have been proposed and effectively reduced mud loss (Aston et al. 2004, Song and Rojas 2006, Whitfill et al. 2006, Aston et al. 2007, Morita and Fuh 2012). There are three main fracture-based strengthening techniques widely used in the industry, fracture propagation resistance (FPR) (Fuh et al. 1992; van Oort et al. 2011), stress cage (Alberty and Mclean 2004) and fracture closure stress (FCS) (Dupriest 2005). The fundamental idea of induced fracture techniques, which seal the fracture at the tip or fracture mouth, is to increase FROP after plugging by wellbore strengthening materials (WSM). Thus, the accurate prediction of fracture geometry is important for PSD selection.