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Wellbore Strengthening without Propping Fractures: Analysis for Strengthening a Wellbore by Sealing Fractures Alone

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Abstract

Incorporating particulate lost circulation materials (LCM) into drilling fluids for drilling weak formations to prevent lost circulation has been in the spotlight in the drilling industry over the last few years. This new technology sometimes is referred to as "stress cage". Creating a stress cage[1,2] can increase the wellbore pressure containment which effectively widens the mud weight window. The mechanism has been explained as propping small fractures intersecting the wellbore resulting in an increase in the hoop stress.

However, a series of studies[3,4,5,6] with a numerical method have indicated that increasing wellbore pressure containment does not necessarily require the propping of the fractures. Merely sealing the fractures alone can also improve the wellbore pressure containment substantially. This paper presents detailed discussion of those factors related to improving wellbore pressure containment by sealing the fractures only. Focusing on fracture stability, studies have found that fracture pressure, fracture length, Young's Modulus, wellbore radius and sealing location can all affect wellbore pressure containment, and the fracture width that exists under each condition shows how challenging it could be to achieve the sealing during implementation.

Introduction

With a greater worldwide demand for energy, drilling activities have been moving into unconventional areas such as deep or ultra-deep water, deep or ultra-deep wells, extended reach wells, in-field drilling through highly depleted formations, etc. These drilling activities typically may encounter mud weight windows that are narrower than usual. The possible severe consequences include hole collapse, lost circulation, stuck pipe, and loss of the drilling interval or even the entire well.

In recent years, a new concept to widen the mud weight window for drilling was introduced[1,7,8] and it is now often referred to as "wellbore strengthening". While methods for coping with narrow mud weight window challenges can differ, strengthening the wellbore for higher wellbore pressure containment seems to be the most economical, preferably strengthening the wellbore to prevent mud losses.[9] A newly introduced wellbore strengthening method to prevent mud losses, usually referred to as "stress cage"[2,10] is a process of adding particulate LCM into drilling fluids to enable the wellbore to withstand a higher pressure without failing. The initially proposed theory has been debated; however, success has been achieved in the field consistently. While we agree that propping fractures will improve wellbore pressure containment (WPC) based on the knowledge gained from the research, more studies have found that sealing the fractures alone still will improve WPC substantially.[3] In many cases, the WPC achieved has been high enough to satisfy the drilling needs of a problem interval. In this paper we will report our findings on the factors that affect achieving a desired WPC by only sealing the fracture. New understandings[9] of wellbore strengthening have provided an improved basis for designing a product and defining its placement techniques and have led to a series of innovations.[10,11]

Method

This study has been conducted within a linear elasticity domain with the assumptions of rock homogeneity and isotropy. These assumptions are commonly used in wellbore stability studies.