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Design of Improved High-Density, Thermally-Stable Drill-In Fluid for HTHP Applications

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Abstract

As we approach an age of deeper discovery and petroleum producing wells with hostile environments, the industry need for an elevated-temperature, high-density, low-solids, and non-damaging reservoir drilling fluid or "drill-in fluid" has moved to the forefront of laboratory and applied research. Drill-in fluids are a special class of drilling fluids that prevent formation damage, provide superior hole cleaning, and help minimize wellbore cleanup effort, resulting in increased efficiency from the production reservoir. These fluids address the wide range of difficulties encountered in horizontal drilling, completion, and workover operations.

The need for fluids with service temperatures above 300°F has increased beyond the capabilities of traditional bio-polymers to create rheologically stable fluids. While some water-based drilling fluids excel at these higher temperatures, their formulations include non-acid soluble solids that are damaging to hydrocarbon-bearing formations and hence undesirable. With higher temperature reservoirs being drilled, there is need for a suitable high-density, high temperature stable drill-in fluid.

For the development of the fluid presented in this work, various high density brines were evaluated to achieve fluid weights up to 17.6 ppg (2.1 sg) in order to reduce the amount of weighting agent utilized in the system since these solids can result in high plastic viscosities and create difficulty in the cake removal and clean-up processes. The total amount of $CaCO_3$ bridging material was maintained at a relatively low concentration to produce a thin, acid-soluble filter cake while the bridging particle size was determined by the ideal packing order of the chosen pore size.

The improved drill-in fluid was shown to possess thixotropic fluid rheology. Its additives are based solely on synthetic polymeric material for increased chemical and thermal stability. Hot-roll temperatures in excess of 355°F (180°C) were achieved with no loss in rheological properties.

Introduction

Advancements in drilling and completion technologies for improved returns on drilling investments have led to the development of radically new categories of drilling and completion fluids. Advanced drilling technologies, like high-angle, multilateral, slim-hole, and high-temperature, high-pressure (HTHP) extreme environment wells require fluids that provide maximum performance by maintaining effective suspension properties and a non-damaging behavior over a broad spectrum of conditions.[1-3] Therefore a need exists for an improved drilling fluid system that meets both drilling and completion requirements and can be successfully applied for drilling operations in complex formations and under extreme thermal and pressure conditions.

Over the last decade, major service companies have devoted extended research towards the development of a specialized category of drilling fluids for utilization within reservoir sections.[4-13] The employment of such fluids has become an accepted best practice within the petroleum industry. Commonly referred to as reservoir drilling fluids (RDF) or drill-in fluids, these particular formulations are specifically designed to help prevent formation damage, minimize rig time, and provide maximum production efficiency. Although aqueous- and hydrocarbon-based fluid systems exist, brine-based drill-in fluids encompass the vast majority of RDFs used in field operations to date.[14]

Engineering a brine-based drill-in fluid system with the preferred performance characteristics for extreme environments (particularly deep well and HTHP applications) has continuously presented a host of challenges for operators and has been the subject of continued field and laboratory research. A successful reservoir fluid would ideally prevent formation damage, provide superior hole cleaning, and allow for effortless cleanup resulting in increased efficiency from the production reservoir Therefore, one of the keys to the design of the fluid system and optimization of wellbore productivity by retaining the natural