Improved drilling fluids advances operations

UNDERSTANDING APHRONS

APHRON DRILLING FLUIDS are being used globally to drill through depleted reservoirs and other underpressured zones. The primary features of these fluids are their unique low shear rheology and aphrons (specially designed pressure-resistant microbubbles of air). However, how aphron drilling fluids work is not well understood, which limits acceptance of this technology. Recently a study was undertaken under the auspices of the US Department of Energy to gain understanding of aphron drilling fluids. This presentation will showcase results of the study.

Various laboratory techniques were applied to determine the physicochemical properties of aphrons and other components in the fluid and how they affect flow through permeable and fractured media. These included wettability and surface tension, bubble stability, radial and dynamic flow visualization and fluid displacement tests.

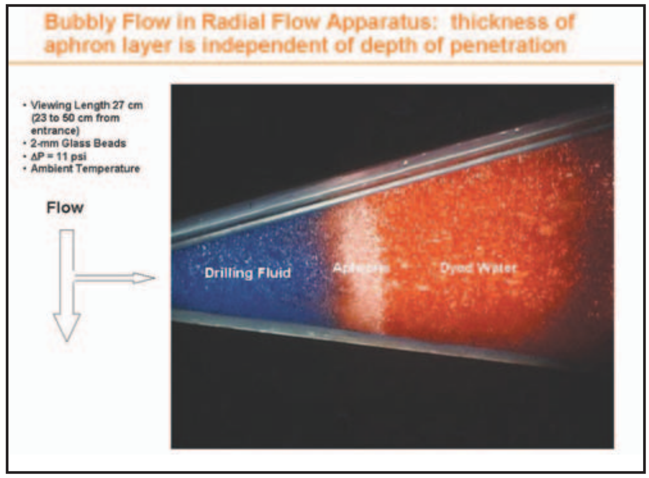
One key discovery was that aphrons can survive compression to at least 4,000 psi, whereas conventional bubbles do not survive long past a few hundred psi.

When drilling fluid is lost into a loss zone under the drill bit, aphrons move faster than the surrounding liquid phase and quickly form a layer of bubbles at the fluid front. At the same time, the shear rate of the fluid is continually decreasing and the viscosity is rapidly rising. The combination of the bubble layer and the rapidly increasing viscosity of the liquid severely curtails fluid invasion.

Another key finding of the study is that aphrons show little affinity for each other or for the mineral surfaces of the pore or fracture. Consequently, the seal they form is soft, and their lack of adhesion enables them to be flushed out easily during production.

Depleted wells, which are very expensive to drill underbalanced or with other remediation techniques, can now be drilled overbalanced. This study has provided a sound technical basis for the success of aphron drilling fluids and is providing guidance on the way to run these fluids in the field to optimize their performance.

Recent Advances in Aphron Drilling Fluids (IADC/SPE 97982) FB Growcock, M-I Swaco; A Belkin, MASI Technologies LLC; M Irving, B O'Connor, M Fosdick, M-I Swaco and MASI Technologies LLC; TL Hoff, MASI Technologies LLC.



97982: Although aphron drilling fluids are being used around the world, how they work is not well understood in the industry.

CONTINUOUS CIRCULATION

A Continuous Circulation Valve (CCV) was developed for enabling drilling in depleted reservoirs at HP/HT fields in the Norwegian sector of the North Sea. By utilizing a system to obtain circulation through the whole drilling operation, the downhole pressure will remain constant even during drillpipe connections. By balancing this downhole pressure between a maximum pore pressure and a minimum fracture pressure, drilling can be performed properly even through narrow drilling windows.

The valve is a two-position, three-way ball valve. It is possible to circulate through the valve from the top drive down the drill string or through a side port and down the drill string. Such a valve must be installed at the top of each drill pipe stand before the continuous circulation operation starts. When a connection is to be performed, a hose must be connected to the side inlet of the valve, the flow from the mud pumps will then be switched from the top inlet to the side inlet, and top drive can then be disconnected and a new stand installed. To continue drilling, the operation is reversed. The valve is designed to withstand HP/HT pressures, including gas-filled casings, bull heading and maximum pressure during standard drilling operation.

A prototype of the valve has been produced and operation tested on the full-scale research drilling rig Ullrigg in Stavanger, Norway. The current paper presents the advantages gained by using the CCVs in a drilling operation. The formation types most vulnerable for drilling problems while drilling depleted reservoirs are described.

Continuous Circulation During Drilling Utilizing a Drillstring Integrated Valve — The Continuous Circulation Valve (IADC/SPE 98947) A Torsvoll, K Bekkeheien, I Kjellevoll, Statoil; N Reimers, Sensor Link; P Horsrud, DH Breivik, Statoil.

MANAGING BARITE SAG

Barite sag is a well-recognized but poorly understood phenomenon in the drilling industry. Industry experts have offered a variety of measuring parameters based on empirical data that only partially correlate with the occurrence of barite sag.

The development and introduction of standardized well-site techniques to predict the onset of barite sag in dynamic flow has evaded the industry.

The effect of shear rate on dynamic barite sag has been studied and quantified using new and advanced technology. Changes in mud weight as a function of shear rate, hole angle, annular velocity and eccentricity correlate with ultra-low shear rate viscosity. Field-proven technology has been developed to predict the potential for barite sag and to provide remedial measures through ultra-low shear rate viscosity modification.

This technology was originally developed and validated in the field with invert emulsion drilling fluids. Subsequent verification and validation work showed the technology was equally valid for water-based drilling fluids. This innovative technology is well suited for use with a variety of commercially available field viscometers and therefore lends itself to widespread industry use.

The paper will discuss the theoretical basis for this barite sag management technology and present the viscosity levels with corresponding shear rates required to manage barite sag. Case histories also will be presented.

Field Proven Technology To Manage Dynamic Barite Sag (IADC/SPE 98167) WM Dye, GA Mullen, WJ Gusler, Baker Hughes.

UTILIZING FORMATE BRINES

Formate brines have been successfully used as essentially solids-free reservoir drilling in and completion fluids in more than 100 HP/HT wells over the past 10 years. These have included 70 cases in which the high downhole pressures have necessitated the use of cesium formate brines for well-control purposes.

Out of these 70 cases of cesium formate brine use in the field to date, 10 have been HP/HT reservoir drilling in and completion operations in high-angle wells where operators considered that the use of traditional fluids might compromise project economics, well safety and well integrity.

This paper looks in detail at the drivers that encouraged BP and Statoil to embark on the use of cesium formate brines as their preferred HTHP drilling and completion fluids in the Devenick, Huldra, Kristin and Kvitebjorn fields.

The paper then reviews the technical and economic performance of the cesium formate brines in these drilling applications and evaluates whether the benefits promised some 15 years ago have been realized.

Drilling and Completing Difficult HP/HT Wells With the Aid of Cesium Formate Brines — A Performance Review (IADC/SPE 99068) JD Downs, Cabot Corp.

SAND-CONTROL TECHNIQUES

A large majority of the recent deepwater/subsea developments in West Africa require sand-control applications. Openhole gravel packing is the preferred sand-control technique adopted by most operators in this region. Since most of these reservoirs contain reactive shale streaks, they require synthetic/oil-based drilling fluids.

Significant progress has been made in recent years toward overcoming the challenges associated with gravel-packing of such wells, through new developments in fluids, tools and techniques. These developments have resulted in successful gravel-packing of wells drilled with oil-based fluids, which have yielded well productivities, which, in many instances, exceeded those completed in water-based drilling fluid environments. Currently, techniques and fluid systems are available for gravel-packing with either a water-based or an oil-based gravel-packing fluid.

Both approaches have been practiced in various regions in the world. A common and critical element of both approaches is the proper assessment of potential plugging of the sand-control screens during installation and subsequent displacement processes, since the screen installation often must be accomplished with solids laden fluids (conditioned OBM) in the wellbore, due to logistical challenges and economics.

An oil-based carrier fluid was recently used for openhole gravel packing of a well in Okpoho field, offshore Nigeria. The application resulted in the best producer in the field. The paper details the steps taken through the design and execution stages of the treatment, incorporating the lessons learned from the two previous applications of the oil-based carrier fluid.

A detailed description of the yard tests conducted in Nigeria will be thoroughly discussed. A critical discussion of the onsite QA/QC procedures with screen samples is also included.

A simple approach is proposed for quantification of the impact of screen plugging test results on field practice. This allows the operators to evaluate how much, if any, screen plugging can be expected with the particular conditioned OBM as the screens are run in hole and during subsequent displacement processes, so that the operator can decide whether further conditioning (additional rig time) is worth the associated cost.

Open Hole Gravel Packing with Oil Based Fluids: Implementation of the Lessons Learned from Past Experiences Leads to the Best Producer in Okpoho Field, Nigeria (IADC/SPE 98151) EP Ofoh, ME Wariboko, Nigerian Petroleum Development Co; F Uwaifo, M Parlar, Schlumberger.

OVERCOMING DENSITY LIMITS

Displacing drilling mud with clear solids-free completion brine is a critical step during well completion. Conventional cleaning fluids use fresh water or seawater treated with surfactants to remove wellbore solids and water wet tubulars. Using low-density cleaning fluids creates a negative differential pressure between the working kill weight fluid and the formation, casing and cement liners. In many situations, the negative differential pressure cannot be tolerated and the risk of failure at the liner top, etc, is increased, especially if the wellbore has not been pressure-integrity tested.

In order to overcome the density limitation of these cleaning fluids, conventional techniques such as additional hydraulic horsepower, back pressure schedules, the addition of solids to lighter cleaning fluids (water, seawater), or balancing the weight of the low density cleaning fluid with a matching higher density fluid is utilized. However, each of these “fixes” has inherent limitations.

New brine-compatible surfactant chemistry and the corresponding balanced displacement engineering design were developed to overcome limitation of conventional displacement technology.

This paper describes the field applications of new brine-based, high-density, solids-free cleaning fluids in balanced displacements in both deepwater and offshore shelf wells. The new high-density fluids were based on new surfactant technology developed to ensure effective wellbore cleaning, wellbore design parameters and displacement modeling. In addition, weighted spacers aid in reducing pump pressures with high differentials.

In one case history, maximum pumping pressure of more than 9,000 psi is expected for a conventional water-based displacement while it was reduced to a little over 3,000 psi with the new design. High-density cleaning fluids, with densities up to and greater than 17.5 ppg, have been produced and utilized successfully without compromising cleanup efficiency and significantly reducing differential pressures. Results from laboratory development and field applications will be presented.

Effective High Density Wellbore Cleaning Fluids: Brine Based and Solids Free (IADC/SPE 99158) PH Javora, GD Baccigalopi, Q Qu, BM Franklin, BJ Services Co.