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Advances in Fluid Sampling With Formation Testers for Offshore Exploration

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Abstract

Formation fluid samples provide valuable information for field development. However, drilling mud filtrate contamination reduces the sample quality drastically, and the current industry technique to obtain clean fluid samples requires a long pumping time. This can be costly, especially in deep offshore wells. This paper presents a new formation fluid sampling apparatus which separates filtrate contamination efficiently from the virgin reservoir fluid; the fluid sample cleans up much faster than with the conventional approach. In addition to the new sampling apparatus, downhole fluid characterization techniques, including contamination monitoring, composition measurement, and single-phase assurance, are presented. These provide real-time fluid property information, and help ensure that representative samples are obtained. Field test results show the value of these new techniques to the sampling process.

Introduction

In the early stages of the exploration and development cycle, high-quality representative reservoir fluid samples provide critical information about the properties of the hydrocarbon fluids, such as gas/oil ratio (GOR), saturation pressure, density, and viscosity. Determining reservoir fluid properties is critical for optimization of the well completion and production facility designs. This is particularly important for deepwater projects, which can be extremely expensive and require the facility decisions to be made early in the project. Wireline formation testing has proven to be a reliable way to obtain these representative reservoir fluid samples.

Contamination from miscible drilling mud filtrate, such as that which occurs when oil sampling in oil-base mud (OBM) wells, remains the biggest challenge to obtaining good reservoir fluid samples. This contamination greatly reduces the sample quality, making subsequent pressure/volume/temperature (PVT) laboratory analysis unreliable and often incorrect. To achieve a clean fluid sample with the current openhole sampling technology, long pumping times may be needed, which can be costly and risky in offshore wells. Additionally, if the mudcake is poor, mud filtrate may continuously invade the formation during sampling, negating the effect of pumping and making it impossible to obtain a clean sample.

A new "focused sampling" apparatus is presented in this paper. The heart of this tool is an innovative formation tester probe design, featuring guard and sample assemblies. With this design, the downhole tool can efficiently separate drilling mud filtrate contamination from virgin reservoir fluid during the sampling process. A clean reservoir fluid sample can be acquired much faster than with conventional sampling technology.

Also presented are techniques for downhole fluid characterization. These techniques include contamination monitoring, fluid type identification, composition measurement, and single-phase assurance. These techniques use data from fluid analyzer tools that measure the absorption properties of hydrocarbons in visible and near-infrared (NIR) spectroscopy. In addition, fluorescence measurement is used to assure a single-phase fluid sample, especially for gas condensates.

Field test results show that the new focused sampling technique can obtain clean fluid samples much faster than with the conventional approach. The tests also demonstrate the value of real-time downhole fluid analysis. Together, these advances in fluid sampling provide high-quality samples and an optimized sampling process.

Background—Conventional Sampling

Previous work describes the design and operation of downhole tools for the purpose of fluid sampling.[1,2] To summarize, historically there have been two methods to obtain formation fluid samples using downhole wireline tools; these methods are shown schematically in **Fig. 1.**

The first method uses the pressure differential between the reservoir and an evacuated chamber to move fluid out of the formation and into a sample bottle. Several variations on this method have been successfully used, including the use of water cushions and throttling valves to control the pressure differential; but the use of an evacuated chamber to induce fluid flow is the same in all cases. The second method uses a downhole pumping system to drive fluid from the reservoir, through the tool, and out into the borehole until a certain contamination level is present in the incoming fluid. At this point, a valve system may be used to direct the incoming fluid to fill one or more sample bottles.