Underbalanced operations

SPE/IADC 52825

"Innovative Use of BHAs and LWD Measurements to Optimise Placement of Horizontal Laterals"

Over 50 horizontal laterals have been drilled in a shallow, heavy oil reservoir in Eastern Venezuela by **Peruozuata C A**, a joint venture between **Petroleos de Venezuela** (**PDVSA**) and **Conoco**. Precise navigation through the formations was necessary to optimize placement of the lateral drainholes and maximize the percentage of reservoir sand exposed. To meet this requirement, an optimized BHA design and LWD measurement system were developed based on field experience.

MWD directional measurements were used to steer the well through the reservoir, along a specific well path chosen from 3D seismic which covers the field area. The LWD azimuthal and bit electrode measurements were integrated with 3D seismic to allow an interactive interpretation of the stratal boundaries present within the reservoir and result in a continuous refinement of the initial well path. Using the information derived from the continuous LWD, bit electrode measurements and Radial Azimuthal Resistivity, the location of shale stringers, bed boundaries, and pay sand relative to the BHA could be determined and the well steered in the appropriate direction to maintain an optimum position within the oil reservoir.

As a result, the number of sidetracks was reduced and the percent sand encountered increased from 52.3% to 65%. The longest horizontal lateral in Venezuela was also drilled and completed as part of this project.

—G Farruggio, Anadrill, et al

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"Underbalanced Drilling in a Depleted Gasfield Onshore UK with Coiled Tubing and Stable Foam"

Drilling infill wells or sidetracking existing wells to new targets in severely depleted reservoirs is a challenge that more and more operators are facing as the UK industry matures and the existing fields decline in pressure. Add to this challenge a low cost requirement for infill drilling combined with a severe lack of suitable equipment and the challenge becomes virtually impossible. It was possible fox a small independent UK operator to overcome all the challenges- Successfully drill a horizontal sidetrack underbalanced in a severely depleted reservoir with coiled tubing on a low budget and still obtain a significant improvement in production. By using existing available equipment and by applying the keep it simple approach the operator was able to

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successfully drill a horizontal sidetrack underbalanced in a depleted gas field. This paper presents the case history including the lessons learned during the planning and operational phases of the well.

The planning of the HM-5 well started in October 1997. The well was spudded in Feb 1999 and operations Were completed in March 1999. The well was reentered and successfully sidetracked with a 7" liner set above the reservoir. The 6" reservoir section was drilled underbalanced using a coiled tubing drilling system with a stable foam circulating system from 1640 ft AHBDF to 2,493 ft AHBDF. The well was completed with a 7" monobore completion. A total of 34 days were required to complete the operations and 12.25 days down time were experienced due to operational problems.

HM5 WAS the first gas well drilled underbalanced with coiled tubing in the UK land drilling operations. From a drilling technical point the well achieved all objectives and was drilled safety underbalanced.

Although a number of improvement areas have been identified, Hatfield Mears 5 can be considered as a success.

Careful pre-planning for underbalanced drilling operations must be carried out to select the optimum methodology. flexibility and lateral thinking is required during the drilling operations to overcome the challenges encountered. Good wellsite supervision saves time and money. Underbalanced drilling with stable foam still requires industry initiatives for optimisation.

—S W Nas, Smedvig Offshore

SPE/IADC 52827

"Successful Use of the Hydraulic Workover Unit method for Underbalanced Drilling"

This paper describes 2 very successful underbalanced drilling operations that were performed in Belgium and in the coastal area of the Netherlands. The underbalanced drilling operations used the hydraulic workover (HWO) unit method to effectively control the well pressure during drilling. This method is unique because it eliminates any damage to the formation and causes very little pollution.

For the Belgian operation, drilling was preceded by a series of tests and simulations, followed by the installation of a hydraulic workover data-acquisition system and the drilling and casing of the well. A 9 5/8-in. shoe was drilled, and a cement bond log was run, after which injectivity tests were performed at the shoe. A bottomhole assembly (BHA) with an 8 1/2-in. test was then used to drill into the reservoir, at which point the well was predicted to go underbalance due to the fresh-water drilling fluids. Even though the pressure was not seen to rise, this operation ran flawlessly and the BHA was retrieved without any problems. The well was then cased with 7-in. liner.

The second case history represents one of the most complex and technically challenging underbalance drilling projects to date due to the offshore environmentally sensitive location in the North Sea and the high BHP of 250 bar. The steps above

were repeated, but this time there had to be zero discharge of gasses or fluids. Some of the precautions included console enclosures, hose cover drip pans and encapsulating the entire hydraulic workover unit. As a result of this drilling procedure, the target fault was crossed successfully while meeting all environmental restrictions and customer objectives.

The success of the method must also be attributed to the operational planning and close attention to experience gained from previous drilling operations from the multi-disciplined crews. The execution of the treatment utilized all the components considered to be state-of-the-art, including the use of a data acquisition system, real-time treatment pressure monitoring and HWO drilling procedures applied.

—R Robichaux, Halliburton Energy Services

SPE/IADC 52828

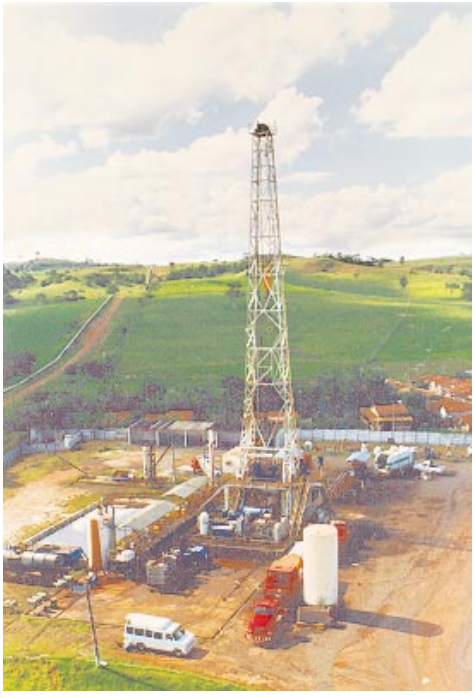
"Underbalanced Mudcap, Efficient Drilling of High-Pressure Fractured Reservoirs"

The Cogollo reservoir in the Urdaneta West concession in Lake Maracaibo, operated by **Shell Venezuela. SA**, is a tight, high-pressure and sour limestone where faults with associated fractures are targeted to obtain good producing wells. Of the 12 conventional wells drilled by SVSA until May 1998, 6 encountered severe losses and 4 did not reach planned TD. Drilling operations included over 100 days losses related to trouble time, with more than $12 million spend in rig time and mud. The ever-present dilemma in fractured reservoirs is that the large fractures, which provide the high production potential, cause severe drilling problems due to lost circulation. Curing the losses with conventional or novel lost circulation material can cause severe production damage, in addition to consuming considerable rig time for each and every fracture penetrated. Underbalanced drilling equipment and techniques, whilst highly successful in low-pressure reservoirs, are not (yet) designed to handle the high surface pressures of a prolific high-pressure fractured reservoir. Merging traditional mudcap techniques with the pressure control philosophy from underbalanced operations offers a safe and efficient operation under these unpredictable conditions. This paper describes the problems associated with conventional and underbalanced drilling, the technique of underbalanced mudcap drilling, and the fast-track implementation by SVSA in the offshore, high pressure and sour Cogollo reservoir.

—R Urselmann, Shell Venezuela SA

SPE/IADC 52829

"Full-Scale Experimental Study for Better Understanding of Transient Phenomena in Underbalanced Drilling Operations"



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A transient hydraulics simulator for underbalanced drilling can contribute significantly either for designing an UBD operation or to define the most appropriate operational procedures. Timing for flow stabilization, pressure peaks in the returns and pressure variations at the bottom of the well are some of the aspects involved in determining the adequate injection flow rates, separation system and drilling procedures. A full-scale experimental investigation was planned and executed to provide data for the evaluation and improvement of transient underbalanced drilling computer simulators. The tests were performed in a 1,272-m vertical well in a research facility in Brazil. The experiments involved the injection of liquid and gas through a 3-in. drill-string (ID = 2.375 in.) and the return of the mixture via the annulus between the drill-string and a 7-in. casing (ID = 6.366 in.). First, a pulse consisting of a gas-liquid mixture with high velocity was injected. The available data acquisition system in the research facility kept track of the whole evolution of the gas distribution inside the drill-string and through the annulus. A sequence of 2 gas-liquid pulses was pumped and analyzed as well. In addition, saw-tooth pulses were also injected. A proper combination of liquid and gas injection rate was selected. After reaching the steady state, gas-injection rate was gradually increased with a build-up period of 10 minutes. Then, the steady state was achieved again, starting a gradual decrease of gas pump rate. These tests revealed some important aspects about the flow behavior: (1) how gas spreads along flow direction due to sudden changes in gas fraction; (2) gas rise velocity as a function of gas fraction; and (3) occurrence of gas accumulation inside the well related to the positive and negative gas fraction slopes. This information gives support for the perfecting of the numerical schemes used to solve the conservation equations.

—A V M Lage, E Y Nakagawa, Petrobras
–R W time, Hogskolen I Stavanger
–R Rommetveit, E Vefring, RF-Rogaland Research

SPE/IADC 52832

"Planning an Effective Aerated Drilling Operation in Hard Formation Based on Cost Analysis"

Many advantages of air/mist foam drilling related to penetration rate in hard formation have been pointed out in many papers of the oil business. There are no questions regarding the improvement in the penetration rate when using this technique, but questions rise when the main topic is the savings brought by the aerated drilling operation. The answers for those questions are not clear once many of the involved economical factors depend on each particular case, and in some situation the operator may not have all the necessary data on hands for choosing the best option between an aerated or conventional drilling. Among the necessary data for an appropriate cost analysis in drilling a hard formation, it can be cited the drilling rig day rate, the air drilling equipment day rate, the air equipment diesel supply. the air equipment set up and set down time, the hard formation thickness, and the expected penetration rate.

This paper presents a real analysis performed for a wildcat well in Colombia using all the previous cited necessary data where there were uncertainties related to the hard formation thickness and the expected penetration rate. It also presents how all the involved costs were treated for a more realistic analysis about the drilling technique choice, with the respective equations and graphs for cost analysis. Finally the paper presents the real results collected during the aerated drilling operation, where all the forecast values were compared with the real ones for a validation of this technique.

—A F Negrao, Halliburton Energy Services
—N A Duarte, Petrobras

SPE/IADC 52833 (ALT)

Underbalanced Drilling Gains Acceptance in Europe and the international Arena Generally"

Underbalanced drilling commenced in Europe in 1993 with coiled tubing projects in the UK and offshore in the North Sea. 2 jointed pipe projects followed in Germany in 1994-95.

The major milestone for underbalanced drilling came in 1996 with the first offshore jointed pipe project in the North Sea by **Shell**. Since 1996 other offshore wells have followed in the North Sea and onshore projects in Holland, Italy and Spain. Further afield, projects are in progress in Indonesia Venezuela and Argentina.

The paper will review the development of underbalanced drilling as a natural extension of horizontal drilling technology and its acceptance by many operators internationally as becoming the only way to address difficult drilling and formation damage issues. The paper will also review the current status of the technology with regard to Rotating BOPs, Surface Separation facilities, tripping and completing under pressure including Rig Assist Snubbing. The adaptation of directional drilling, MWD /LWD systems for underbalanced drilling will be covered in the paper.

—B J Gedge, Northland energy Services■