Bit design solves performance and drilling challenges

MAXIMIZING DRILL RATES

THE AUTHORS WILL present results of an effort to use real-time surveillance of mechanical specific energy (MSE) to maximize drill rates. The usefulness of MSE analysis in lab environments is well established. The intent of the project was to determine whether it might be equally useful to rig-site personnel.

The results exceeded expectations. Of the 12 ExxonMobil wells drilled by six rigs in the pilot project, 11 were record wells. Interval drilling days were reduced by 25-60%. A strategy is currently being developed to extend MSE surveillance practices to other operations.

MSE is a calculated value equal to the ratio of the input energy to the drill rate. Because a given volume of a specific rock requires a given amount of energy to destroy, this ratio should be relatively constant. Any significant increase in the MSE ratio is taken as an indication that energy is being lost and the system has become less efficient. The drilling information provider supporting the project has modified its system to display the calculated MSE continuously for real-time analysis, either on a time or depth log. The ROP is optimized by conducting drill rate tests and utilizing changes in the MSE ratio to detect bit founder, or energy loss due to the onset of vibrations. Following the tests, the maximum operating parameters are maintained at which the MSE shows the bit to still be efficient.

MSE analysis allows the optimum operating parameters to be identified easily, and more or less continuously for each foot of hole drilled. Secondly, it provides quantitative data needed to cost-justify changes in areas such as well control practices, bit selection, BHA design, makeup torque, directional target sizing, and motor differential to further extend the limits of performance.

Maximizing Drill Rates with Real-Time Surveillance of Mechanical Specific Energy (MSE) (SPE/IADC 92194) **F E Dupriest**, **ExxonMobil**; **W L Koederitz**, **MD/Totco**.

COMPRESSIVE STRENGTH

It has become standard practice to plan wells and analyze bit performance based on log-based rock strength analysis. There are several methodologies in use that characterize rock strength in terms of "confined" compressive strength, but the most widely used standard used by drill bit specialists is "unconfined" compressive strength. The use of unconfined compressive strength (UCS) is somewhat problematic in that the apparent strength of the rock to the bit is typically something different than UCS. There is awareness of the problem, as it is widely accepted that bit performance is greatly influenced by mud pressure and the difference between mud pressure and pore pressure. However, there is not an industry standard or widely used methodology for accounting for these effects. The impact and potential cost of this problem is magnified in the deeper and harsher environments the industry is facing.

Optimizing PDC bit designs and the way the designs are applied has improved significantly, resulting in considerable savings to operators. SPE/IADC 91782.

A globally applicable solution and methodology has been developed and is in use by **ChevronTexaco**. The method involves log-based workflows and a combination of conventional and somewhat innovative rock mechanics principles. In this context, global means the method is robust, based on fundamental and/or first principles, requires little or no calibration (any required calibration is simple and intuitive), and lessons learned in one location can be applied anywhere else. The authors will present the new methodology, the results of analysis of field and lab data which validates and quantifies the degree of improvement in using the new method, and case histories that illustrate the problems of using UCS and the benefits of the new method.

New Confined Compressive Strength Calculation Leads to Improved Bit Selection, Performance, and Prediction (SPE/IADC 92576) **W M Calhoun**, **H U Caicedo**, **R T Ewy**, **ChevronTexaco**.

PERFORMANCE EVALUATION

The author describes a method developed to represent the inherent drilling difficulty posed by the combination of rock properties and depths and pressures that make up a field's drilling environment, thereby facilitating like for like comparisons of drilling performance from different fields. This method potentially fills a major gap in the drilling industry's benchmarking capability by providing an objective basis for assessing whole-well bit performance.

Data were analyzed from 10 wells in seven different onshore and offshore locations around the world. These wells were selected as good benchmarks for the performance achievable in their drilling environments. Three measures were used to represent drilling performance in these wells: total dry hole (excluding coring, logging and completion activities) days per 1,000 m, normal drilling days per 1,000 m, and rotating days per 1,000 m. These measures showed wide variations, reflecting the range in drilling difficulty posed by the different geological environments. However, the rotating days per 1,000 m showed encouraging correlation with the wells' technical limit specific energies. The other performance measures also showed clear trends when plotted against technical limit specific energy.

These trends can be used to evaluate drilling performance achieved in other wells or fields. The performance measures for the new well are compared with the benchmark performance trends at the new well's technical limit specific energy, revealing whether the drilling performance departs substantially from the expectation for a well of similar drilling difficulty.

Technical Limit Specific Energy-An Index to Facilitate Drilling Performance Evaluation (SPE/IADC 92318) **D A Curry**, **Baker Hughes**.

OPTIMIZING BIT PERFORMANCE

Optimizing PDC drill bit performance has been greatly improved over the past three decades. Not only have the designs changed considerably but also the way in which these new designs are applied has improved significantly, passing on considerable savings to the drilling operator. The next leap forward in drill bit optimization will probably be due to high-speed real time optimization of the drilling parameters to avoid down-hole situations that limit the performance of these improved designs. Vibrations such as lateral, axial and torsional accelerations may damage the cutting structure and therefore limit penetration rates. Avoiding these vibrations is essential to increase the bits durability and improve the overall drilling economics.

The authors describe one set of independent drilling optimization results obtained as part of a series of controlled drilling tests managed by Sandia National Laboratories on behalf of the U. S. Department of Energy. A Cooperative Research and Development Agreement was established involving several bit companies to illustrate the optimization process involving real time decisions while drilling through hard rock. All bit companies involved were furnished with identical information regarding the formation lithology, rig capabilities and also the real time run information from a base line bit, before designing their best effort design.

The choice of design for this application utilized ultra-wear resistant TSP cutters that performed extremely well in the hard and abrasive formations encountered. The results indicate that traditional methods of modifying the drilling parameters to improve performance based on WOB, RPM and torque readings do not always provide the true picture of what is taking place at the bit. Instead, a holistic approach combining traditional methods of optimization together with high-speed real time data enables far better decisions on improving bit performance and avoiding damaging situations that may have otherwise gone unnoticed.

Optimization of PDC Drill Bit Performance Utilizing High Speed Real Time Downhole Data Acquired Under a Cooperative Research and Development Agreement (SPE/IADC 91782) **T S Roberts**, **A E Schen**, **ReedHycalog**; **J L Wise**, **Sandia**.

MATURE FIELD BENEFITS

Drilling through the complex geological structures of the southern Oklahoma Marlow field with their highly dipping formations presents a number of distinctive challenges. Operators typically employ a conventional directional system (motor) to keep inclination to a minimum in the 8 ¾-in. vertical hole section.

However, this type BHA has led to unacceptable angle building tendencies/dogleg severity and poor vertical hole quality resulting in directional issues in subsequent hole sections. The motor assembly increases well costs due to multiple correction runs resulting in more flat time, lower average ROP and more bits/runs per section.

To address these issues, a drilling optimization service conducted a detailed analysis of drilling performance, mud logs and wireline data from offset wells.

This helped identify potential problems and led the operator to set objectives for the 8 ¾-in. vertical hole section to achieve the highest possible ROP while maintaining a near-vertical wellbore. A strategy was developed that had two main components, including a sophisticated straight hole drilling device (SDD) with a reduced exposure PDC bit.

The system has also reduced torque/drag, delivered a smooth quality wellbore, and eliminated costly correction runs. The increased wellbore quality has allowed the operator to log and set 7-in. casing to bottom without incident. Apache has experience increased performance when kicking off below a section drilled with the SDD/bit combination, improving directional control and aiding geosteering to the target reservoir.

Mature Field Benefits from Application of High-End Technology (SPE/IADC 92624-Alternate) **M R Isbell**, **Hughes Christensen**; **G E Bone**, **Apache Corporation**.

INSTRUMENTED DOWNHOLE TOOL

The authors describe a short, autonomous, instrumented downhole tool that incorporates multiple sensors (accelerometers, strain gauges and magnetometer), a complete data acquisition line, a microprocessor, memory chips and batteries. The tool is available in three sizes (7, 9 and 10 ¼-in.) and can be located anywhere within the BHA including behind a motor or rotary steerable system as its total exposed length is only 350 mm. At a scanning rate of 50 Hz (up to 250 Hz), the tool records 100 to 300 hours of torque, axial force (or weight-on-bit) and one bending moment as well as centripetal, tangential and axial accelerations used to reconstruct the instantaneous bit kinematics (RPM, off axis rotation, side acceleration).

Two Isub prototypes were successfully run in 12 ¼-in. and 8 ½-in. size holes. The data reveal the occurrence of phenomena (vibrations, motor performance) neither detected nor suspected on surface. It also captures all inappropriate drilling practices.

The analysis shows strong evidences of the tremendous potential of such a tool not only to gain a better understanding of the drilling process but also to provide an objective measure of the drilling performance, improve drilling performance and build best drilling practices rules.

Isubs: A New Generation of Autonomous Instrumented Downhole Tool (SPE/IADC 92424-Alternate) **C Coudyzer**, **Polytechnique**; **U T Richard**, **S D Desmette**, **Diamant Drilling Services**.