Drilling mechanics

SPE/IADC 52819

"Field Data Supports the Use of Stiffness and Tortuosity in Solving Complex Well Design Problems"

Torque and Drag analysis has been used for more than 10 years to drill wells "on paper". Representations of the drillstring and bottomhole assembly (BHA) that do not include the individual component stiffness have been used with some success in analyzing and preventing problems in extended reach drilling. As curve rates have increased in directional wells, the effects of the previously neglected stiffness have led to errors in the sideforce calculations that underpin all torque and drag analysis. Full finite-element analysis can solve this problem. Additionally, tortuosity can be added to provide a rippled effect to a well plan that simulates the micro doglegs that occur in the drilled well, enabling more realistic bounds to be placed on the drag and torque losses and the forces experienced by the drillstring.

We discuss 3 field cases in which a model including stiffness and tortuosity aided decisions and helped to reduce costs.

Based on data for 4 wells at Hibernia, torque and drag comparisons were made between silicate and polymer water-base and oil-base drilling fluids, highlighting the need for the increased lubricity of the oil-base system to facilitate sliding and keep within equipment limits on specific higher displacement wells.

In a 3,700-m TVD well with a 6-km displacement, we show how the model can be used to optimize drillstring design and balance the high Von Mises stresses indicative of this type of well profile.

Thc reentering of existing wells to drill a horizontal drainholc usually requires a sidetrack section with a high build rate. Stiffness calculations helped to clarify the buckling considerations needed to drill a series of reentries in the Gulf of Mexico.

—A Hendricks, Anadrill/Hibernia Integrated Well Services
–I M Rezmer-Cooper, Schlumberger Oilfield Services

SPE/IADC 52820

"Consequences and Relevance of Drillstring Vibration on Wellbore Stability"

Wellbore instability problems have been attributed mainly to rock-fluid interaction, especially when drilling shaley formations with water-base fluids. However, recent studies (Santos, 1997) showed that other events during drilling may contribute much more decisively in causing the problems than the rock-fluid interaction and swelling. The drillstring vibration is one of these events. Identification of the real cause of the problems is essential to reduce the exploration costs in challenged environments, such as the ones faced today by the oil industry.

The paper briefly presents a conceptual model to analyze wellbore stability based on energy. Even though there are 4 main energetic events during drilling, this paper is focused in just one, drillstring vibration. A method to quantify the energy associated with the vibrations and how this energy is transferred to the wellbore walls is presented. Measurement of vibration was conducted in 2 wells in the Amazon region in hard and fractured rock. The paper presents the results obtained from these measurements, taken on the surface, showing strong vibration in one of the wells. The caliper log clearly shows the correlation between the intensity of vibration and borehole enlargement. In this case, rock-fluid interaction cannot be blamed as the cause, since the rock is clay-free. It is also shown that in the well without vibration the caliper is almost in gauge.

After investigating several possibilities for the cause of instability in the region, it was decided to take a closer look at the influence of vibration, to check if this might be the real cause. Based on the results presented, recommendations to be done in future wells are described. Suggestions in terms of drilling fluids are also made, since this can contribute decisively to strongly reduce the incidence of the problems. However, the adopted solution should be in a completely different direction from what has been done so far.

—H Santos, J C R Placido, Petrobras

SPE/IADC 52821

"Analysis of the Stick-Slip Phenomenon Using Downhole Drillstring Rotation Data"

The stick-slip phenomenon has been identified in the industry as an inefficient and often damaging drilling vibrational condition. Numerous studies, predominantly focusing on measurements of drillstring torque, have detailed the nature of this phenomenon, and have shown its detrimental effects on drillstring components and especially on PDC bits. Using surface rotary motor current, drilling contractors and surface logging companies have attempted to monitor drillstring torque so as to recognize and correct for this torsional instability

Recent MWD tool developments using downhole drillstring rotational speed have established a superior method to identify stick-slip and establish its severity. Measuring actual rotational behavior of the lower BHA gives a better insight to the torsional movement of the drill bit during thc drilling process, without the problems involved when inferring this behavior from surface torque readings, obtained at the opposite end of the drillstring.

This paper describes the method of determining the stick-slip behavior downhole from magnetometer readings. The sensors are sampled at a high enough frequency to compute near-instantaneous values of downhole drillstring rotation, and variations in the RPM are then used to establish the incidence and seventy of stick-slip. This information is then telemetered to the surface and provided to thc driller in order to allow for real-time changes in drilling parameters to correct for this inefficiency. Also presented in the paper are several examples using actual field data that detail stick-slip behavior and demonstrate how real-time information about downhole RPM variations can help to reduce the problems associated with this torsional drilling dysfunction.

—E Robnett, et al, Baker Hughes INTEQ

SPE/IADC 52822

"Drillstring Considerations for Gulf of Mexico's Deepest Well (27,864 ft)"

EEX Corp, a Houston-based petroleum exploration and development company, suspended drilling operations at Llano, a Garden Banks Block 386 Deep Miocene test in 2,663-FT of water, after setting a 7-in. liner at 25,145 ft. The 25,145-ft casing shoe was the deepest in the Gulf of Mexico, but the Miocene objective was deeper still! Potential well control pressure for continued drilling exceeded 10,000 psi.

Therefore, the Diamond Offshore Ocean Voyager was released in January 1998 after setting a 7-3/4-in. subsea tieback casing string. The Sedco Forex Omega with 15,000 psi BOP equipment became available in March 1998, and was utilized to successfully perform deepening/sidetrack operations for Miocene evaluation.

The plan was quickly generated for slim hole drilling a Gulf of Mexico depth record well. The short fuse project required "Out Of Box" thinking practices with successful implementation. A slimhole drill string with ample tensile/torsion capacity, sufficient flow area for hole cleaning, and immediate availability was utilized in an "edge of envelope" environment with remarkable success. The paper discusses the factors involved in string selection/acceptance, actual field data, post well results, and future application.

—T E Prater, EEX Corp, et al

SPE/IADC 52823 (ALT)

"Dynamic Behaviour of a Bit-Motor-Thruster Assembly

Case studies of thruster assemblies show that the use of a thruster in the bottomhole assembly of a drillstring is beneficial for the operator because of a considerably improved rate of penetration and smooth drilling conditions. From a technical standpoint, the axial dynamics of the drillstring is improved by the use of a simple thruster device. The thruster acts like an "Anti Vibration" tool.

Laboratory measurements of a full scale assembly containing a bit, a downhole motor and a thruster were undertaken in order to quantify the forces, accelerations and dynamic pressures at 6kHz sampling rate and different operating conditions. The signals are analysed with means of digital signal processing techniques in order to determine the dynamics characteristics. Transfer functions specify the system behaviour.

The measured vibration response is used to calibrate unknown parameters of a bit-motor-thruster dynamics time domain simulation software that includes mud flow forcing effects. The application then successfully predicts the dynamic behaviour of a complete drillstring during drilling.

—B Schmalhorst, Baker Hughes INTEQ

SPE /IADC 52824 (ALT)

"Pyro Technology for Cutting Drill Pipe and Bottomhole Assemblies"

In recent years, limited advances have been made in existing drill pipe recovery services technology. The "back-off" technique has been the preferred method because it results in a clean top on the downhole fish. Other high-explosive devices normally require additional trips into the well to clean off the top of the fish, if it can be redressed.

This paper introduces now technology for disengaging pipe located above the point where the drillstring assembly is stuck. The system uses a solid combustible mixture, a unique Teflon application, and a patented pressure balance anchor. Both the Dupont Corp and the United States Department of Energy have publicly acknowledged the system's market potential in the oilfield services.

The cutting device consists of a thermal generator, which initiates the deflagration process, tubular housing containing the solid-solid mixture, a nozzle, and pressure balance anchor. When the internal temperature of the device reaches 1,100° F, the solid combustibles ignite. Ignition causes the solids to then oxidize, increasing the temperature to 6,000° F. Teflon is the source for the required gas pressures and thc nozzle discharges the molten metal and gases radially against the pipe to be cut. The pressure balance anchor is used to maintain the tools stationary position during the cutting procedure.

The tool is safe to store, transport and handle at temperatures up to l,100° F environment.

—J Cole, Western Atlas Logging Services