ReedHycalog taking holistic approach to mitigating drilling vibrations to reduce NPT

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DRILLING VIBRATIONS HAVE been identified by many operators as the leading cause of nonproductive time. With the current strong rig rates, nonproductive time, ranging from drilling inefficiencies to twisting off the drill string due to fatigue failure, has become even more critical.

Symptoms of vibration problems that lead to nonproductive time are:

• Drill string failures, including twist-offs and washouts.
• Overtorqued drill pipe connections.
• Premature bit failures, poor and erratic bit life.
• Downhole drive system failures or performance inefficiencies.
• Logging tool failures.

All have been attributed to damaging dynamic conditions, such as bit whirl, pipe whirl and stick-slip.

Rather than address these issues individually, ReedHycalog has adopted a more holistic, process-orientated methodology. ReedHycalog Drilling Dynamics Solutions attack this problem by prediction, recommendation, implementation, validation and documentation.

PREDICTION

In the VibraSCOPE Drill string Dynamics Modeling Software, the user enters the details of the drill string and BHA and imposes a force input, and the software processes the information using a finite element model that predicts those parameters that will likely cause resonant axial, lateral and torsional vibrations. The output identifies critical weight and RPM ranges that avoid resonance and reduce the risk of initiating damaging vibrations.

Drilling models are also used in the design process. These software tools mathematically model roller cone or fixed cutter bits, attaching them to a drill string and simulating drilling performance. In particular, the tools predict the levels of vibration for specific parameters and formation properties.

Our drilling models allow the design engineer to optimize performance and iterate towards the optimal trade-off between the four fundamental indexes of ROP, stability, durability and steerability for a particular application.

In any application, the well trajectory, drive type and lithology dictate the relative importance of each index. For example, in a directional well in medium-hard formation where high doglegs are required on a push-the-bit RSS:

• Sidecutting is critical so high steerability is required.
• Durability is not vital so a lighter set bit would be adequate.
• A stable bit is critical to maintaining the RSS, MWD and LWD tools, so stability is vital.

Hence the optimal bit for this application will need to have high steerability and stability indexes, with lower levers of durability and ROP. The design engineer can use the ranking of the importance of each index to make the best trade-offs during the bit design process.

RECOMMENDATION

From the predictions come recommendations from solutions packages, including Demanding Drilling Solutions, Hard Formation Solutions, Large Diameter Solutions, Hole Opening Solutions, SystemMatched Directional Solutions, Coring Solutions and Drilling Dynamics Solutions.

IMPLEMENTATION

Mitigation of vibration is a crucial part of the Drilling Dynamics Solutions. The unique geometry of the V-Stab vibration dampening tool provides a mechanism for disrupting resonant vibration modes, reducing the number and magnitude of shocks that occur during the drilling process. The V-Stab tool disrupts vibration because its asymmetric cross-sectional geometry provides:

• Variable freedom of movement of the drill string during the drilling process.
• An eccentric mass that applies centripetal forces to the drill string.
This combination of variable movement and centripetal forces breaks up resonance and dampens the magnitude of the shock waves.

Originally designed to assist in the stabilization of bi-center bits, the V-Stab tool has been proven to increase bit life and ROP in a variety of drilling applications. Placement of the V-Stab tool in the drill string is critical so the BHA geometry and wellbore trajectory must be taken in to account to achieve maximum effectiveness.

In a recent deepwater well in the Gulf of Mexico, the V-Stab tool was run with a bi-center bit and subsequently with concentric hole openers. One concentric hole opener run did not utilize the V-Stab tool. Downhole vibrations were monitored on all three runs. Torsional vibration, lateral vibration and peak shock levels were all reduced by over 50% compared with the run without the V-Stab tool, enhancing ROP, footage and ultimately reducing the associated drilling costs.

**VALIDATION**

Measurement of the actual drill string dynamic behavior is extremely important due to the complex nature of the drill string and wellbore interaction. To fully understand the effects of the drill string geometry, drive type and other downhole tools, actual measurements are taken during drilling operations with the BlackBox Downhole Dynamics Recorder.

At just 2 ¾ in. in diameter, BlackBox’s small size allows for flexible placement in multiple locations, if required, along a single drill string. This tool allows for post-well analysis of dynamic behavior of the drill string, enabling recommendations to optimize the drilling process. It has been utilized on more than 150 runs and has a recording capacity of approximately 200 hours.

In one application in Oklahoma (see above graph), the BlackBox tool was run in conjunction with both a rotary steerable tool and a straight motor in the same BHA. As the tool was a push-the-bit system that needed to be as close to the bit as possible, the BlackBox recorder was run above the RS tool but below the motor. High levels of stick-slip were observed, leading to the bit being pulled out of hole and changed.

The dull bit showed no mechanical cutter damage, as would be expected if the bit had been subject to severe stick-slip in the relatively competent formations it had been drilling.

The BlackBox data helped identify that the cause of the stick-slip was not the bit. The rotational speed of the tool did show significant fluctuations (with a minimum to maximum variance of up to 200 RPM), but the actual minimum rotary speed measured never fell below 95 RPM.

The minimum of 95 RPM was significant as that was the calculated RPM of the motor being used at that particular flowrate. Since the BlackBox was located below the motor, this was conclusive proof that the bit was not the origin of the torsional vibration issues, but rather that something above the motor was the contributing factor.

Further analysis showed that on drilling into a sandstone, the level of stick-slip did not increase until the bit was 50 ft into the formation. This coincided with the placement of the first string stabilizer above the motor. In this case, the drag caused by the stabilizer entering the sand was the cause of all the stick-slip observed. It is noteworthy that on the subsequent bit run, where no stick-slip was seen, this stabilizer had been laid down and not replaced.

Another application through interbedded lithologies used the traditional slow speed, high torque motor (7:8 lobe, 5 stage, 0.16 revolutions/gallon). However, there was evidence of both stick-slip and bit whirl despite the use of a motor. BlackBox data conclusively showed that the bit was suffering from stick-slip. A change to a higher speed motor was recommended to reduce stick-slip. On the next well the same bit design and the higher speed motor (0.29 revolutions/gallon) were used to achieve a significant improvement in ROP along with the elimination of stick-slip.

Subsequent runs with this same combination did not show any of the torsional vibration damage seen in previous runs and set field drilling records resulting in significant savings for the operator.

The use of BlackBox analysis in this and other studies shows that changing bit designs is not always the solution to the drilling challenge. A more complete recommendation, including changes to the drilling system, was the answer.

The BlackBox recorder data has also been compared with the VibraSCOPE software prediction to validate its accuracy. These tools show positive correlations, providing further confidence in the methodologies for vibration prediction and validation.

**DOCUMENTATION**

The final stage of ReedHycalog’s holistic approach is documentation. The results of the previous four stages are reviewed, any suggested further improvements are proposed, and lessons learned are captured. This stage closes the loop, allowing individuals all over the world to benefit from knowledge submitted to our Knowledge Management Software Tool, InSight.

Additionally, the results of the lessons learned are fed back to the customer and service companies involved in a drilling project.

This holistic approach to predicting, mitigating, implementing, validating and documenting drilling vibrations is at the forefront of this technology. ReedHycalog’s Drilling Dynamics Solutions package offers a reliable methodology for managing the risks associated with this destructive and costly drilling challenge.