System uses downhole data to make operations smarter, reduce job time for well intervention

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TRADITIONAL RIG-FLOOR instrumentation provides an indication of critical job parameters taken at surface. As wells become deeper and more tortuous, surface measurements no longer accurately reflect the forces being exerted on and around downhole tools. This uncertainty about what is happening at the business end of the string often creates inefficient operations and a high exposure to risk, resulting in nonproductive time and increased cost of operation.

To address these issues, a new system has been developed that integrates real-time data into well intervention, allowing operators to make informed decisions and take immediate actions to optimize ongoing intervention operations.

TECHNOLOGY OVERVIEW

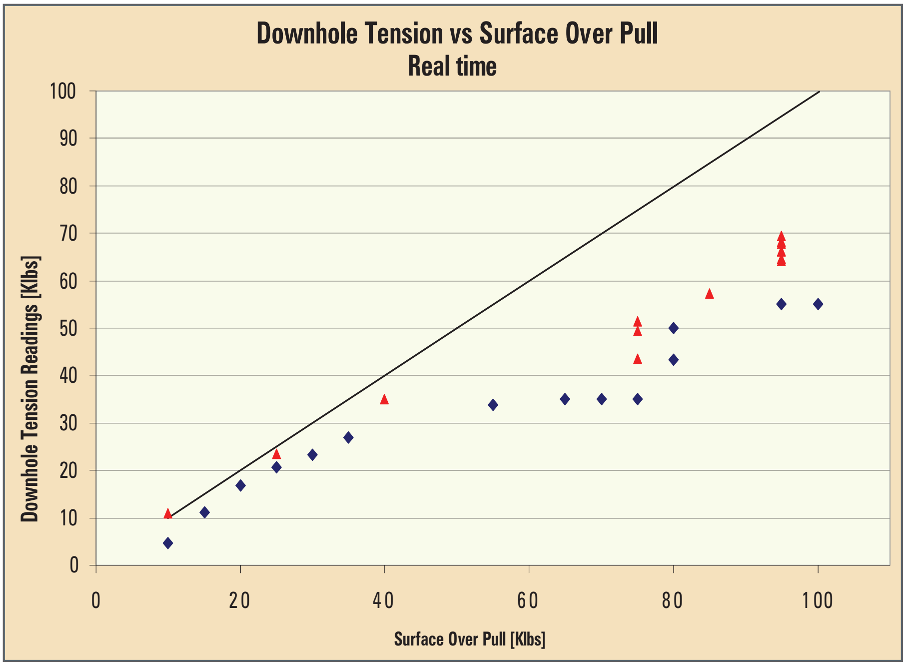
The Smart Intervention system features a downhole data acquisition and processing tool and a power and communication module that uses mud pulse telemetry to transmit data to surface. The system contains an array of sensors, including strain gauges, accelerometers and magnetometers that provide measurements such as weight, tension and torque on tool; RPM; bending moment; vibration; pressure and temperature.

The downhole information is presented to the intervention operator on the rig-floor and can be sent to a remote operating center. Based on feedback from the downhole data alongside traditional surface-acquired data, informed decisions can be made on how to advance in the well intervention operations, i.e., pulling out of hole after confirming successful connection to a “fish,” optimizing milling parameters or working pipe to overcome weight transfer issues.

The system is some 26 ft long and available in 3 1/8-in. through 9 ½-in. sizes. The standard system is set up to operate in temperatures up to 302°F and pressures up to 25,000 psi.

CASES HISTORIES

The system has been applied in various applications in deepwater Gulf of Mexico. The cases discussed here include fishing for a light fish, casing exit operations, weight transfer tests and fishing / jarring application.



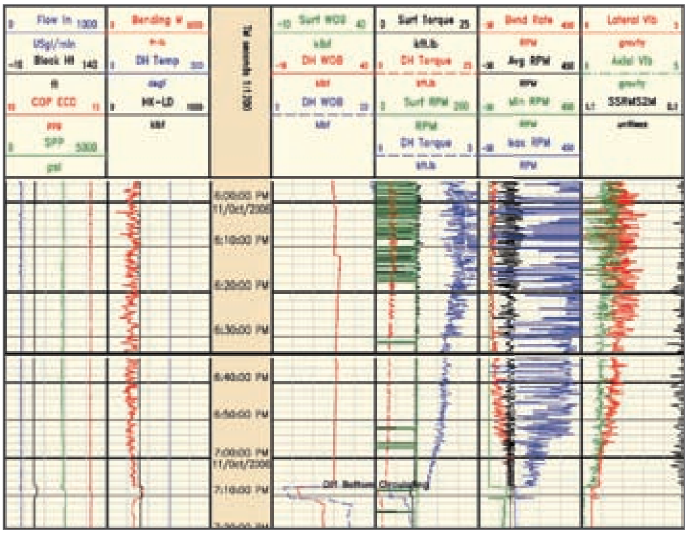


Figure 1 (above): Downhole tension vs surface overpull data confirmed an anchor latch was free downhole (case study 1). Figure 2: A log excerpt from a milling operation showed surface gauges couldn’t accurately reflect the severity of the downhole condition (case study 2).

Case study 1

The first case study is from a fishing operation with the objective to fish a 260-lb (air weight) anchor latch positioned at a depth of 14,500 ft and an inclination of 45°. Figure 1 provides an overview of the downhole tension versus the surface overpull as seen from the real-time data. For instance, while pulling 60 klbs from surface, the downhole tension is only some 32 klbs, i.e., a substantial amount of pull is lost to friction in this instance. With the use of the downhole data, it could be verified that the downhole overpull exceeded the necessary shear values, and a 240-lb increase was visible on the downhole data in real time, confirming that the anchor latch was free. With confidence, the fish could be retrieved with no further delay in the operation.

Case study 2

The system was utilized on milling BHAs for window-milling operations. In this case, the data was only stored to memory and therefore the operation was carried out relying purely on surface-acquired data. The memory data showed

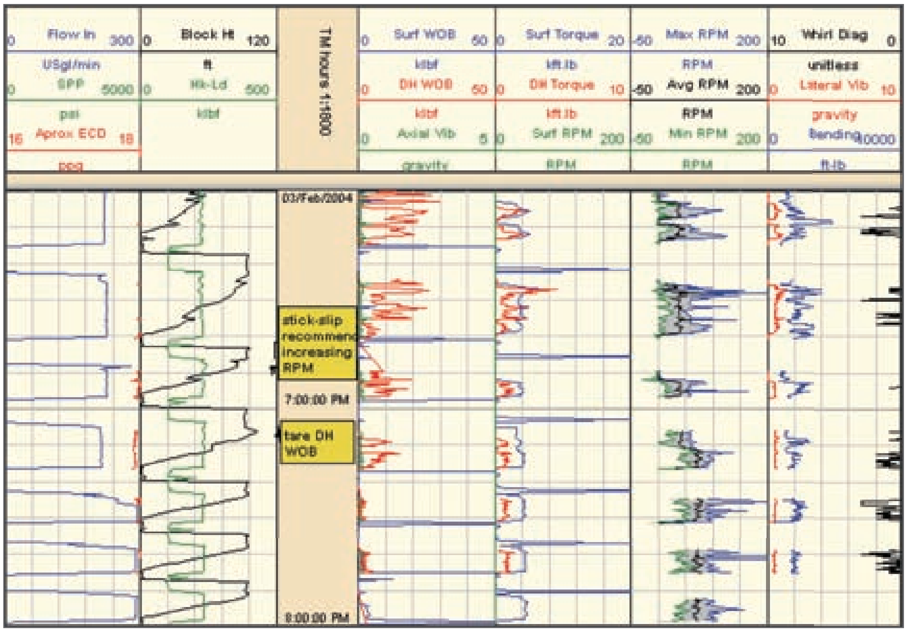


Figure 3: A log excerpt of a milling operation shows that although stick-slip and higher levels of vibration occurred, the situation was able to be mitigated through active parameter management using downhole information sent up in real time (case study 3).

Figure 4: The mill was pulled in good condition after active parameter management to mitigate stick-slip and vibration (case study 3).

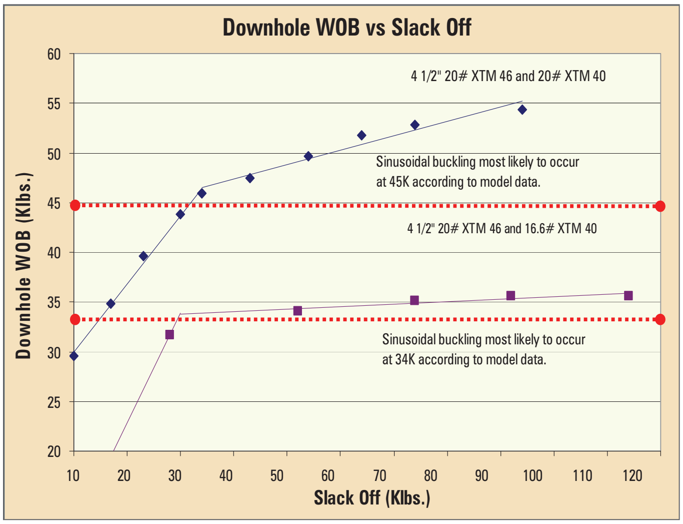


Figure 5: In an offshore extended-reach well using the smart intervention system, downhole weight measurements versus surface slack-off data helped determine that the drillstring design was insufficient to handle the application (case study 4).

harsh downhole conditions, with excessive stick-slip and axial vibrations. As can be seen in Figure 2, the surface RPM was kept around 100-120, but the downhole RPM varied between -20 to 450.

Lateral and axial vibrations of some 3 g-RMS, with peak values up to 15 g were also experienced. Although some torque variations were seen on the surface gauges, it did not accurately reflect the severity of the downhole condition. This resulted in a prematurely dulled mill, and two runs were needed to complete the exit and drill the required length of open hole.

Case study 3

The system was again utilized on a milling BHA for a casing exit, but this time the data was sent to surface in real time. The parameters were promptly adjusted whenever high vibrations were experienced or when energy to the mill was lost.

As shown in Figure 3, stick-slip and some higher levels of vibration occurred, but the situations could be mitigated through active parameter management. The downhole bending moment was also utilized to monitor the quality of the window. One possible problem, early jump-off, was detected and WOB was promptly adjusted to mitigate that possibility. The window and some 175 ft of formation were completed in one run. The mill was pulled with very little damage, as shown in Figure 4.

The measured bending moment was compared with the predicted bending moment provided from a proven finite element modeling program. The measured values correspond well with the predicted ones. This information provided valuable information with regards to the quality of the window and validated previously published whipstock severity figures.

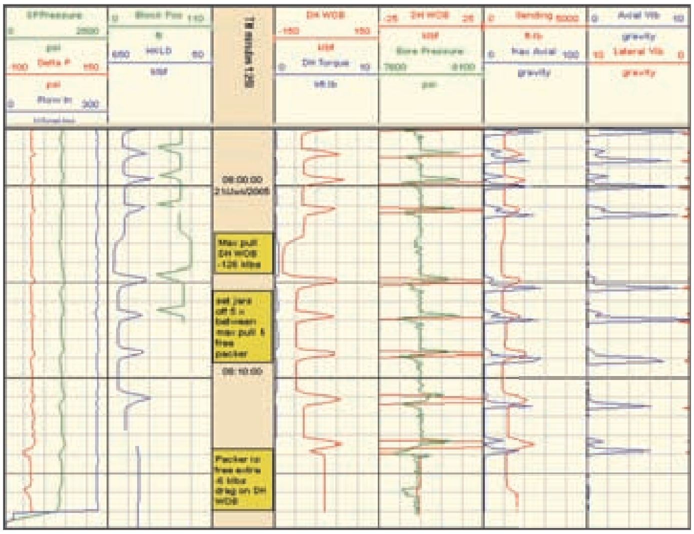
Case study 4

The completion plan for an offshore Gulf of Mexico extended-reach development well drilled in 3,214 ft of water presented an unusual situation. A 60 klb downhole compressive load was required to hold the gravel pack assembly in place at nearly 25,000-ft MD. The extended-reach well geometry proved problematic. Modeling the drillstring created uncertainty as to the capability of the chosen string to deliver the loads needed before buckling. To decide whether the string was fit for purpose for the application, it was decided to run the smart intervention system to understand the ability to reliably transfer the needed loads to the end of the drill string.

The downhole measurements showed buckling before the required weight could be applied, so the drillstring was changed to add stiffness. With the modified string, the job could be carried out successfully.

Sinusoidal buckling points predicted by torque and drag software were validated by the downhole measurements transmitted to surface. The downhole tool showed rapid break-over in weight transfer capability after sinusoidal buckling was initiated, as shown in Figure 5. The delivered data showed the original drillstring design to be insufficient for the task, provided proof that

Figure 6: Log excerpt from jarring operation shows each stroke on the jar and the bending moments, giving the operator confidence to continue the operation and later confirmed the packer was loose. It was then successfully pulled out of hole (case study 5).



the redesigned drillstring would handle the loads, and facilitated a successful completion.

Case study 5

A fishing operation with the goal to pull a packer in one run from an extended-reach well was carried out utilizing the downhole smart intervention tools. Once the jarring operation started, it became apparent that there were no visible signs of the jar stroking on the surface measurements. However, each stroke on the jar and the bending moment were clearly seen in the transmitted downhole data, both on the downhole weight curve and from the axial vibrations (Figure 6).

With this knowledge, the operation continued with confidence, and after eight strokes on the jar, an additional six klbs drag were observed in the downhole data, confirming that the packer was loose. The packer was successfully pulled out of hole with no further delay in the operation.

CONCLUSIONS

The smart intervention system has been run in various deployments in deepwater Gulf of Mexico. Measurements have confirmed that in deep, high-angle wells, actual downhole conditions can differ significantly from what is indicated by traditional surface measurements. The real-time information from this system allows informed decisions to be made during intervention operations, which in turn results in a more efficient and reliable execution of intervention programs. These features significantly reduce risk exposure by minimizing the number of runs and reducing the time needed to execute downhole operations.

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This article is based on a presentation at the IADC Drilling Gulf of Mexico Conference & Exhibition, 5-6 December 2007, Galveston, Texas.