NOV's Integrated Drillstring Measurement System Definitively Improves Performance by Providing Data to Autodriller Control Loops

Innovation in action

A client operating in the Far East needed to use precise autodriller control to minimize drilling dysfunction, maximize tool life, and optimize performance. The StringSense integrated drillstring measurement system was chosen to address the client's unique issues.

Typically, measurements made as part of the control loop have been located remotely from the drillstring. These measurements suffer from physical system states that are not directly related to the forces on the bit. The StringSense system, through implementation in the jack-up's drawworks control system, provided the client with more representative and repeatable measurements. Significant improvements after using the system through a three-phase testing and analysis methodology included:

- ROP increases of 10 to 50 ft/hr (3.04 to 15.24 m/hr), with higher magnitudes achieved at deeper depths
- Reduced WOB error by up to two times, with higher reductions again seen at deeper depths
- Improved time domain and closed-loop system characteristics
- Statistically decreased axial acceleration magnitudes for the entire well set

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Technology

NOV's StringSense™ integrated drillstring measurement system provides a means of making surface measurements directly on the drillstring and using that data to develop a complete picture of the drilling process from downhole to surface. As a patented instrumented internal blowout preventer, the StringSense system delivers more accurate and dependable surface drilling data and allows clients to extend the operating envelope when drilling near the technical limits of their wells.

Performance

The StringSense system was integrated into the drawworks control system for weight-on-bit (WOB) autodriller control in a Far East drilling operation. Integration and testing was accomplished in three phases:

1. Integration, system operational/safety evaluation, and sensor characterization
2. Performance testing with the StringSense system feeding the WOB control loop
3. Extensive testing in WOB mode

After concluding the three test phases, the client determined that a typical well-by-well analysis would not suffice in this application due to the limited use of the deadline anchor sensor for WOB control. As such, data was analyzed from a statistical perspective in which metrics for drilling performance, controllability, and dysfunction were functions of depth. A total of 13 wells between the second and third phases were analyzed, providing a comprehensive overview of how the StringSense system affected performance.

Results

The client achieved more consistent control of weight transferred to the drillstring from improved system stability and sensitivity, thus improving rate of penetration (ROP). ROP improvements occurred across the entire depth range, with magnitudes increasing from 10 to 50 ft/hr (3.04 to 15.24 m/hr), and were most pronounced at deeper hole depths. This confirmed that the StringSense system can facilitate efficient extended reach drilling. WOB error was smaller, with a twofold reduction seen at deeper hole depths, and time domain and closed-loop system characteristics were also improved. In addition, axial acceleration magnitudes decreased statistically for the entire well set.

Continuing to tune and filter the StringSense system for autodriller optimization and integrating additional StringSense system measurement data (torque, rotation speed, and pressure) will provide the client with further performance enhancements on future well campaigns.

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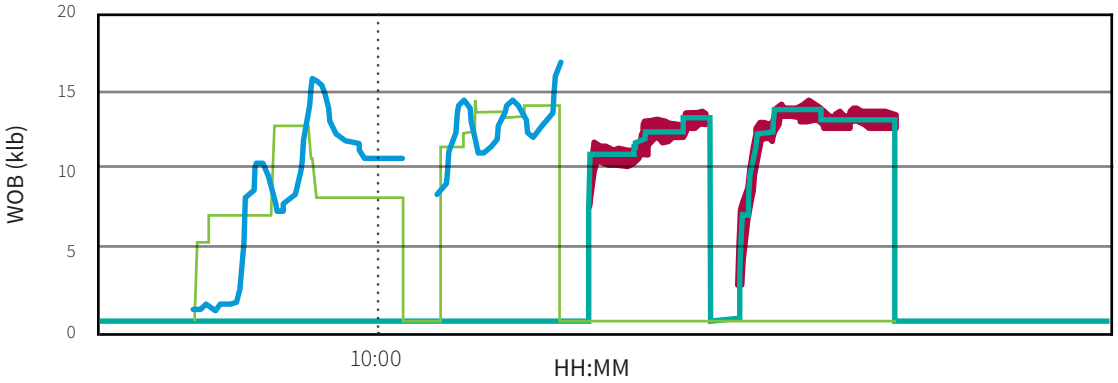

Figure 1 – This time series comparison graph shows system response with the StringSense system engaged (maroon), which illustrates improved metrics such as rise, time, overshoot, and settling time.

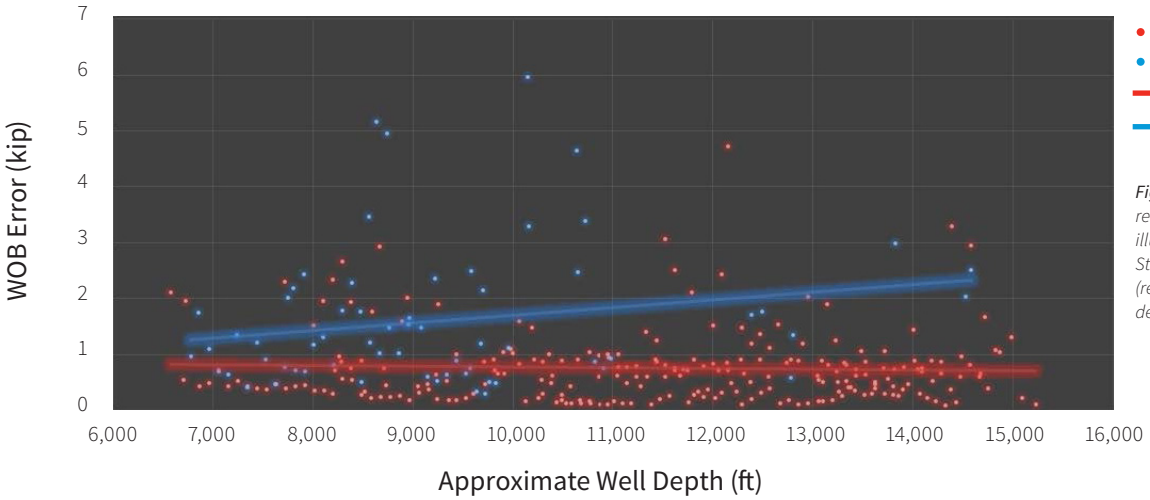

Figure 2 – The WOB control error results for all wells correlate with ROP, illustrating lower error when using the StringSense system with the autodriller (red trace) and trend divergence at deeper depths.

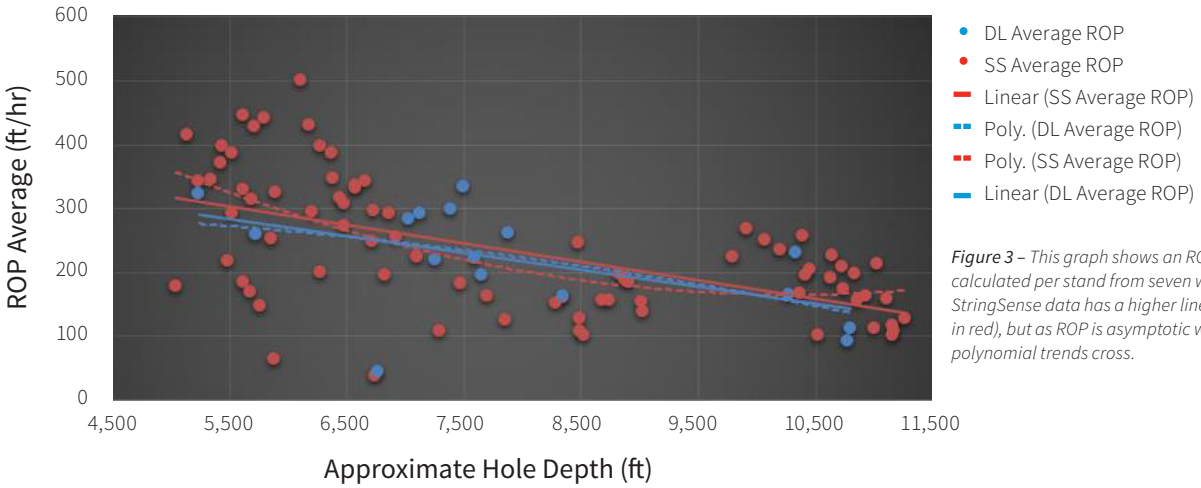

Figure 3 – This graph shows an ROP scatter calculated per stand from seven wells. The StringSense data has a higher linear trend (shown in red), but as ROP is asymptotic with depth, the polynomial trends cross.