Predictive Friction Factors for Frac Plug Drillouts - Permian/Appalachia

CHALLENGE

Completions operations in extended laterals presents challenges with tripping to total depth, applying weight down / pull up, and rotary torque. Numerous technologies have risen to assist with pushing the envelope for reliable completions operations, but evaluating what is possible prior to the operation is challenging. A combination of three technologies applied when drilling out frac plugs in Permian and Appalachia horizontals are evaluated in this case study: hydraulic completion units (HCUs), torque and drag (T&D) software, and data acquisition systems (DAS).

SOLUTION

Post-job analysis can be used to produce accurate predictive friction factors for future offset wells. By removing the primary assumption used in T&D models, a set of friction factors have been established for the Permian and Appalachian Basin for a particular service provider.

RESULTS

In addition to identifying prior to the completion operation whether or not the operation would be possible, accurate predictive friction factors have identified when alternate weight stick pipe was needed, saved operational time be preventing unnecessarily conservative washing schedules and correctly identifying problems that allowed for a tailored solution. Accurate T&D models also generally assist with identifying optimal methods for mitigating torque.

When HCUs (snubbing units) are used instead of coiled tubing, they typically use 2 ⅜” or 2 ⅞” jointed tubing (stick pipe) and require a power tong to make connections. The advantages of using stick pipe include the ability to rotate the tubing string and apply higher forces moving in and out of the well. Coupled with rotation, stick pipe can also achieve higher annular velocities that improve hole cleaning.

Figure 1: Hydraulic Completion Units (HCUs)

As the friction factor (FF) is the largest uncertainty when running predictive T&D models for a well, establishing a friction factor from post job analysis from offset wells can greatly increase the accuracy of a model. The next page are two examples of the many post-job friction factor calibrations run for this analysis. Actual surface torque values recorded by the DAS on the HCU, which are mapped against the surface torque predicted by T&D model at a range of friction factors to establish the friction factor that was present for rotational torque both at the start of the lateral, and after torque mitigation techniques were used (washing, RPM changes, pumping viscous pills).

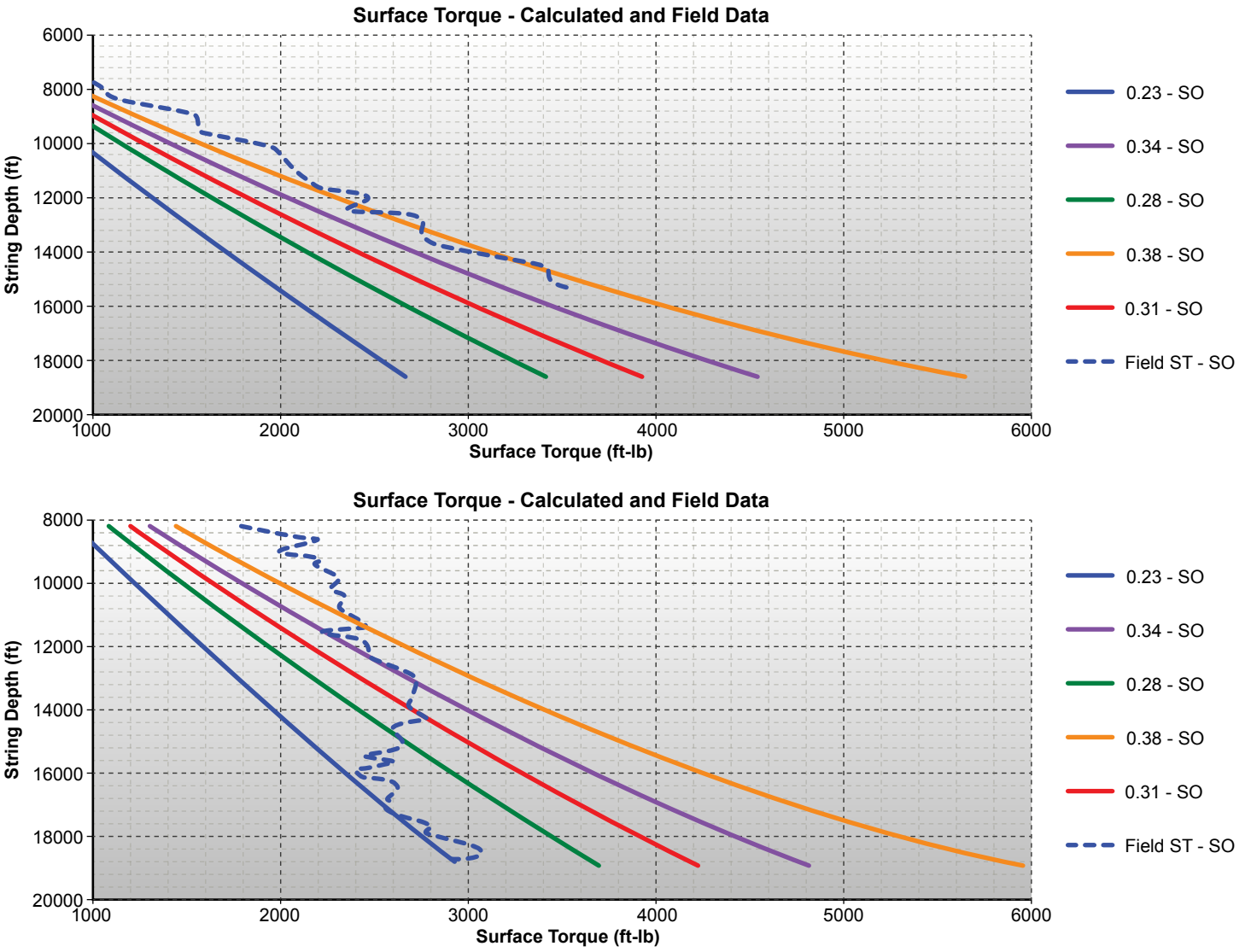

Figure 2: Friction Factor Calibration Using HCU Surface Torque Data

Predictive Friction Factors:

	Permian	Appalachia	Appalachia less A3
Lateral Entry	0.31	0.35	0.33
Operationally Adjusted	0.26	0.27	0.26

Figure 3: Predictive Friction Factors Prior to and While Operationally Mitigating Torque

The primary use of predictive T&D results for drilling out frac plug in these wells has been identifying when larger/heavier string components might be needed for the vertical section, or lighter, thinner walled tubing needed for the lateral section. Other benefits included saved time by optimizing washing schedules and providing information precise enough to accurately identify problems and optimize solutions. Accurate T&D models also generally assist with identifying wells where the logistical, commercial, and technical trade-offs are worth embracing in an effort to mitigate torque.

This case study is reproduced using data also provided for publication of SPE 204410 in cooperation with Deep Well Services (deepwellservices.com)