ENHANCING RSS OPERATIONS

Danny Perez and Stephen Forrester, NOV, show how combining friction reduction with RSS tools can improve performance in directional and complex wellbores.

In its quest to drill more high-value prospects and achieve higher production levels, the oil and gas industry is always on the hunt for new technologies that can increase efficiencies. The need to improve drilling economics has only been exacerbated as WTI price equilibrium continued its rocky ride through the low US$40-range in December 2017, to finally settle around US$60 in April 2018. It is well understood that to get more production out of a well, one must pinpoint geosteering into the well's sweet spot to maximise recovery. The advent of the high-performance rotary steerable system (RSS) has made accurate wellbores more common, but it is not always possible to meet objectives with just an RSS. In such cases, National Oilwell Varco (NOV) has found that adding an Agitator™ tool to the drilling system can provide significant drilling performance benefits, including better steerability, improved wellbore quality, and reduced downhole vibration.

RSS benefits and limitations

RSS offers specific advantages to operators looking to overcome directional challenges. Conventional drilling systems, which typically use a motor, have a bent housing and stabiliser on the bearing section. This configuration allows the motor to drill in either sliding or rotary mode depending on the demands of the well and

desired well path. Though using this setup is sufficient in many scenarios, in others higher performance is necessary to achieve drilling success per the operator's plan.

Drilling continuously without having to slow down or stop to change direction means uninterrupted forward power with consistent weight on bit (WOB). Additionally, the RSS enables higher quality logging-while-drilling (LWD) data collection and eliminates the extra time necessary to align toolface between the drilling modes of a conventional system. Typical wellbore profiles from wells drilled with an RSS do not show the transition areas that result from switches between sliding and rotating with a conventional system. This is critical, as the goal when using an RSS is to achieve cleaner, faster, and more accurate wellbore placement to maximise well productivity.

Using an RSS, however, is not without difficulties and challenges. Even though the drilling system is dynamic when an RSS is in the hole, there will be a constant and unavoidable loss of energy to the formation in all directional applications, and there can be impact damage to the drill bit's cutting structure due to inconsistent reactive torque. In addition, BHAs relying on an RSS sometimes have weight transfer challenges and difficulties reaching total depth (TD) targets on long laterals and complex 3D wells. Torsional vibration and severe stick/slip are also reported very frequently with RSS assemblies. Because of the challenging nature of wellbores where an RSS would be chosen, the risk of damage to BHA components is greater than usual, and repair costs for an RSS, measurement-while-drilling (MWD), and/or LWD system are typically very high.

Complementary technology

The Agitator system introduces a gentle and consistent axial oscillating motion to the drillstring to keep it moving. This simple action is designed to reduce downhole friction and improve weight transfer to the bit. The Agitator system is compatible with all downhole motor, RSS, and MWD/LWD systems regardless of well profile and depth.

Pairing the system with an RSS is a novel new application of the technology designed to bring together the strengths of both tools. Introducing the system to an RSS BHA improves directional control while helping drive a significant reduction in stick/slip and torsional vibration. Adding an Agitator system to the string also enables consistent WOB transfer and reduces unnecessary WOB, improving drilling efficiency and reducing pipe/BHA component wear. In addition to enhancing RSS performance and drilling parameter control, the introduction of the system also extends overall downhole tool life and mean-time-between-failure metrics. Results from using the system and RSS combination show a reduction in reported hanging issues as well as a cost reduction from the use of lubricants.

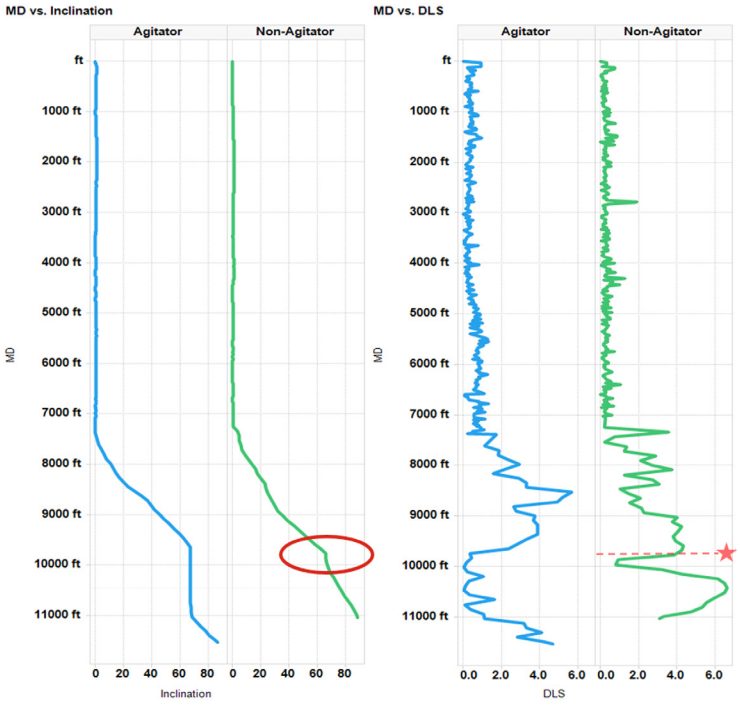

Figure 1. *The maximum dogleg severity for the well with the Agitator and RSS was lower than the dogleg severity for the well without the Agitator for a similar well profile. As shown here, the conventional BHA had more difficulties steering, resulting in unplanned high doglegs and, consequently, increased well tortuosity and poor hole quality.*

Case studies

Middle East: United Arab Emirates

In a project in the Middle East, a customer needed to maintain rate of penetration (ROP) and improve directional control while running a paired Agitator and RSS with the same parameters (WOB and RPM) as used in the offset well. The 6 ¾ in. Agitator tool was placed 1149 ft behind the bit, and a major international directional drilling company's point-the-bit RSS was used. In the subject well, the combination BHA was used from 7501 to 11 535 ft measured depth (MD). This was compared against the offset well, which had only the RSS in the BHA and was drilled from 7204 to 11 040 ft MD.

Both wells were drilled from the kickoff point to the landing point. The combination BHA experienced dramatically reduced tangential vibrations throughout the curve, as well as similar ROP despite much lower drilling parameters (WOB, RPM). High-frequency torsional oscillations, considered the most damaging form of downhole torsional dynamics and related to torsional resonance typically located in the BHA when drilling through hard formations (SPE 167968), were significantly reduced in the Agitator/RSS drilling assembly compared to the offset well without the system. In addition, this combination allowed for 25% less total time spent downlinking with 36%

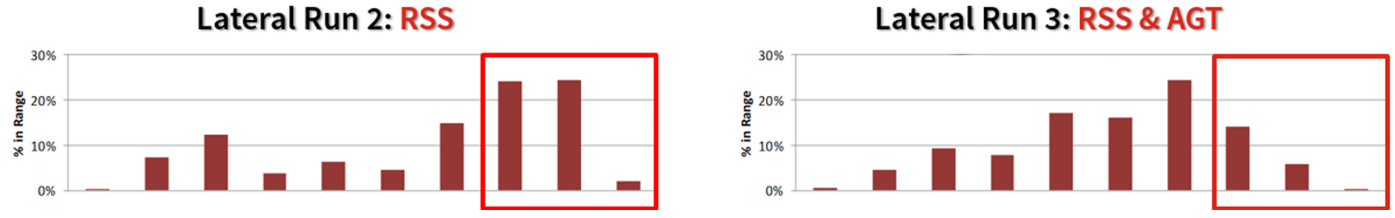

Figure 2. *The run with the RSS spent 50% of the time within the weight range of 23 - 28 000+ lb compared to 20% of the time spent in the same range by the Agitator and RSS combination in the deeper and longer interval, clearly showing that the system improved torque and drag response.*

fewer downlinks, suggesting improved directional control. In the curve section, directional performance was considered a more important metric of success than ROP.

The system reduced shock and vibration in the BHA and improved RSS steerability, leading to drilling efficiency improvements over the offset well. The combination BHA had much better weight transfer than the conventional BHA, delivering competitive ROP with up to 25% lower WOB. 4.1 hrs of nonproductive time (NPT) were saved by reducing the number of downlinks, which also suggests fewer corrections, better directional control, and ultimately improved wellbore quality when using the Agitator and RSS combination.

North America: Northeast USA

A customer in North America was having difficulty with torque and drag challenges and performance limitations with their RSS BHA. They opted to pair a 5 in. Agitator tool with a 4 ¾ in. RSS from another major international directional drilling company in their BHA to overcome these concerns and improve drilling efficiency. The first two lateral runs, from 12 000 to 14 993 ft MD and 14 993 to 17 130 ft MD, were drilled at 88 and 111 ft/hr, respectively. The Agitator system was added to the BHA on the third and deepest run further out in the lateral, which was drilled from 17 130 to 22 310 ft MD at 103 ft/hr.

The BHA with the Agitator and RSS drilled over 60% more footage than the conventional BHAs on the deeper, and therefore most challenging, section of the lateral. Previously, both conventional BHAs had been pulled for severe tool failures. Adding the Agitator system to the BHA helped improve drilling efficiency and operational response across multiple metrics, including differential pressure, weight transfer, and torque and drag. In addition, improved directional control with the combination BHA was inferred by the number of corrections/downlinks, which were decreased to every 235 ft versus the 176 ft and 164 ft of the first two runs.

Drilling efficiency gains also allowed for drilling parameter optimisation and ROP improvements. The ROP breakout on the run with the Agitator system took place at a much lower WOB (13 - 15 000 lb) versus a WOB of 19 - 20 000 lb on the previous run, yielding a reduction in necessary WOB of approximately 25 - 30%. The combination BHA delivered 60% more footage than the conventional BHA, at a comparable ROP, using 15% less weight, 15% less RPM, and 30% fewer downlinks. This happened on the deepest, most complex section of the lateral, and no downhole tool failures were reported.

North Africa: Egypt

A customer with an extremely complex well profile needed to address severe torque and drag and reduce the total number of bit/BHA runs. A 6 ¾ in. Agitator was paired with a 6 ½ in. multi-opening circulation sub (MOCS) and RSS in the 8 ½ in. section to drill through a challenging interbedded lithology of salt, sandstone, anhydrite, siltstone, shale, and limestone. The customer had repeatedly seen BHA hanging issues in the offset wells, and torque and drag values were frequently excessive.

The MOCS was pre-activated on surface as the Agitator was placed above it, and the MOCS tool was successfully cycled to bypass lost-circulation material (LCM) through the annulus. The system allowed for considerably more efficient weight transfer, while adding the MOCS helped to protect the LWD equipment and RSS from LCM. Drag was much lower despite the complex well profile, and the full 8 ½ in. section was drilled in one run. A total interval of 3990 ft was drilled with an excellent ROP of 21.5 ft/hr, even though parameters were controlled in the salt section for directional control and LWD logging.

The RSS assembly run with the Agitator and MOCS achieved a 42% faster ROP than the first offset well and a 20% faster ROP than the second offset well using RSS systems without the technology. These improvements, as well as the substantial reduction in torque and drag and elimination of BHA hanging issues, yielded a cost per foot (CPF) of 42% less than the second offset, saving the customer US$580 000 in costs. In addition, while previous runs had taken 5 - 6 bit/BHA trips, the full section was drilled in one run with the Agitator system and MOCS. The MOCS was successfully cycled 26 times, protecting the costly MWD/LWD equipment and RSS by diverting LCM to the annulus.

Conclusion

Operators will continue to seek better well placement with efficiency gains, reduced equipment damage, and improved geosteering in their drilling programmes. In complicated lithologies and directional well paths with extended lateral sections greater than 10 000 ft, drilling performance and efficiency will remain critical metrics by which a project is deemed a success or a failure. There are numerous options designed to help drill a straight, clean wellbore, and each has its own advantages and disadvantages. Pairing an RSS with the technology discussed in this article is a simple, efficient, and effective way to enhance directional control and increase borehole quality, thus improving completion operations and maximising well productivity and overall economics.

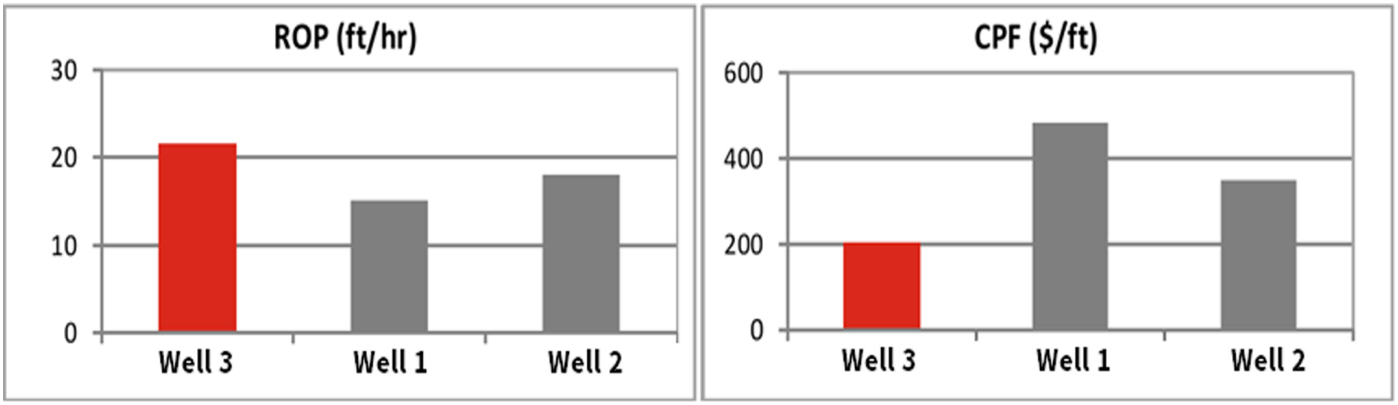

Figure 3. *On the first offset well, ROP was 15.1 ft/hr, and on the second, it was 18 ft/hr. Based on the number of bits used and time downhole, the CPF for the first well was 483.3/ft, and it was 349.3/ft for the second. With the addition of the Agitator system and MOCS, ROP increased to 21.5 ft/hr, and CPF decreased significantly to 204 ft/hr.*