Successful New Technology Introduction and Applications of Rotary Steerable System.

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Abstract

The change from steerable motor to rotary steerable system has been both technically and commercially successful in Libya. Through these case histories the paper will demonstrate benefits resulting from the use of rotary steerable systems that have led to a step change in overall drilling performance in the Middle East.

This paper describes the successful introduction and application of a rotary steerable system for hole sizes (12.25 and 8.5-inch.). The development of rotary steerable capability was seen to be mutually advantageous to both Agip gas and Schlumberger.

The analysis also shows that drilling with rotary steerable systems significantly reduces tortuosity. In tangent sections drilled with the rotary steerable system, wellbore tortuosity can be defined as any unwanted deviation from the planned well trajectory. As wells become more complex, oil companies increasingly perceive wellbore tortuosity as a concern in the process of drilling, completing and producing wells.
Introduction

Rotary steerable systems have progressed dramatically over the past few years as their reliability has improved and the range of applications has increased. The benefits of these systems are well documented. It has become very clear in recent years that the systems play not just a major role for drilling through the reservoir, but also, in optimizing drilling performance to the reservoir.

Steerable motor drilling is a relatively inefficient process, with associated problems in the Middle East area ranging from trajectory control in unstable shales, pipe sticking in lost circulation zones and slide drilling in carbonate reservoirs. Rotary steerable systems are in many cases able to overcome these difficulties through continuous drillstring rotation and optimized bit and drilling parameter selection. Rotary steerable systems are now in use in all common hole sizes from 6" to 17 1/2" allowing problems to be addressed throughout the well.

Initially rotary steerable systems were utilized primarily in extended reach drilling (ERD) wells, where the ability to slide steerable motors was limited by hole drag. Today, drilling engineers are considering such systems for additional reasons. These include performance drilling, improved hole cleaning and geologic steering.

The combination of improved rates of penetration, reduced stuck pipe incidents, enhanced hole cleaning and better hole quality have all contributed to the adoption of these systems in preference to traditional directional assemblies that use motors.

Rotary steerable systems are gaining acceptance in the petroleum industry. As more and more systems become available, the range of potential applications continues to expand.

Rotary Steerable System

Drilling with rotary Steerable motor with a requirement to slide the bottom hole assembly in order to steer the well path drilling becomes slower and potentially more problematical. ROP is impacted as a result of wellbore friction and BHA and drillstring components hanging up. Hole cleaning, without drillstring rotation, is adversely affected, as cuttings will drop out of suspension to the low side of the hole. The transition from slide back to rotate requires rotating the motor bend through the section steered. This can result in hole spiraling.

Steering a steerable motor requires maintaining the orientation of the bend in the desired tool face setting. Reactive torque from the motor itself works against good tool face control with the force turning the string in a counterclockwise direction. The magnitude of reactive torque will depend on the torque being generated at the bit which itself is a function of bit aggressivity, motor torque output and the formation being drilled. Tool face control using a light set PDC bit with large cutter diameter run on a low speed high torque motor can be extremely difficult. As a result a compromise on bit selection is frequently made for steerable motor drilling. It is not unusual for a roller cone bit to be run for a critical directional section of the well due to problems controlling toolface with a PDC bit. Orienting a PDC bit can be time consuming with frequent time spent off-bottom in order to control reactive torque.

The rotary sections with a steerable motor can also result in inefficient drilling. As with a rotary bottom hole assembly the directional behavior of a steerable motor assembly will be a function of stabilizer gauge and spacing as well as drilling parameters used. As a result the drilling parameters will be set to control the directional tendency of the assembly as opposed to maximizing ROP.

Micro-tortuosity associated with a slide rotate sequence is of particular significance in many regional reservoirs. Coiled tubing accessibility can be severely impacted by a tortuous well path in the reservoir. In 6" hole, today's extended power motors are susceptible to formation effects and can be difficult to stabilize and highly tortuous well path can result in the reservoir, often masked by a survey interval of every stand.
Reducing tortuosity through the build section can reap rewards later in the well. Side forces induced by large micro dog-legs from slide rotate drilling will greatly impact torque levels and casing wear later in the well. Fig 1 shows how such sliding dog-legs created large side forces in the 13 3/8 casing while drilling 12 1/4 hole in a well US-285 offshore in UAE. In this case high torque was the issue although the side forces were approaching a magnitude where casing wear could also have become a problem.

Fig 1

For this well we can find high torque came from excessive tortuosity with section have been drilled with steerable motor system as next Graph (Fig 2):

Fig 2
Tortuosity is a source of additional torque and drag while drilling and may result in problems while running casing, liners and completions. In addition, the increase in drillstring-casing contact can add to drillstring and casing wear. In specific applications, excessive tortuosity in horizontal wells can even impair productivity.

Comparing to steerable motor drilling the rotary steerable system should be able to deliver:

- **Increased ROP:**
  - No sliding interval
  - More aggressive bits
  - Optimized used of drilling parameters
- **Reduced trip time through better hole quality:**
  - Improve hole cleaning
  - Reduced tortuosity
  - Improve hole gage

**Drilling 12 ¼ Hole with RSS**

The use of rotary steerable system in 12 ¼ hole first time in Libya is typically used to drill soft formation from Mahmoud to Salambo as mixture of clay and shale of the upper part and marl in the lower part, providing improved directional control and significantly improved penetration rates.

To kick off, build angle to 60-70 deg and hold to 9 5/8 casing setting depth using a steerable motor would normally take a minimum of two bit runs with an average penetration rate in the region of 35 feet per hour. This formation sequence is perhaps a classic for responding to benefits of a rotary BHA.

High penetration rates are achieved through maximizing drilling parameters. using a eight blade PDC bit with 19 mm cutters, such as an RSX130, on a fully rotating system such PowerDrive 900 requires weight on bit to be kept to the top end of the range suitable for the bit: 4.5-13.5 KLBS. Rotary speed should be as high as possible to limit stick slip vibration between 120-140 RPM. These parameters are very difficult to achieve using a steerable motor explaining why the rotary steerable systems drill the section so much faster. The shale ROP have been seen to double purely based on bit hydraulics and with a best performance to date of 60 feet per hour average. Here the benefits of fully rotating system are seen—meaning systems with no stationary or slow rotating external parts. Fully rotating systems assist in hole cleaning and will facilitate tripping in and out of the hole. Frequently additional time saving is achieved through a reduction in tripping time and in particular the eliminations of wiper trips, as well the case at section TD of this example well.

In Libya the recent introduction of rotary steerable system in 12 ¼ hole has been equally significant, The first well to be drilled using a rotary steerable system (PowerDrive900) in Libya was targeted to make a significant reduction in drilling time and consequently cost. Schlumberger drilled first well CC14 for Agip gas, 12 ¼ hole section was drilled in 4.7 days where the plan was 9 days, Agip gas saved around 4.3 days of rig time, and saving 650 K on the AFE cost for this well, Fig3

![Fig 3](image-url)
Since the introduction of 6 ¾ rotary steerable technology in 2000 the envelope has been pushed further still. Wells have now been drilled to measured depths in access of 30,000 feet with 8 ½ drain length of over 25,000 feet. The rotary steerable system brings improved position al control and increased penetration rates with new records. As such rotary steerable drilling is able to meet the challenges:
- Placing the well in the optimum part of reservoir.
- Drilling the longest drain section possible within the reservoir
- Maintain optimum spatial distribution wells.
- Being cost effective.

The use of rotary steerable system in 8 ½ hole first time in Libya is used to drill soft formation from Cherahil B to the top of Metolaoui group as mixture of Shale and limestone, packstone and mudstone, providing improved directional control and significantly improved penetration rates.

To hold 60-70 deg to 7 casing setting depth using a steerable motor would normally take a minimum of three bit runs with an average penetration rate in the region of 30 feet per hour. This formation sequence is perhaps a classic for responding to benefits of a rotary BHA. High penetration rates are achieved through maximizing drilling parameters. Using an eight blade PDC bit with 13 mm cutters, such as an RSX130, on a fully rotating system such PowerDrive 675 requires weight on bit to be kept to the top end of the range suitable for the bit: 4.5-20 KLBS. Rotary speed should be as high as possible to limit stick slip vibration between 120-145 RPM. These parameters are very difficult to achieve using a steerable motor explaining why the rotary steerable systems drill the section so much faster. The shale ROP has been seen to double purely based on bit hydraulics and with a best performance to date of 50 feet per hour average.

The first well in Libya drilled using a rotary steerable system (PowerDrive 675) to make a significant reduction in drilling time and consequently cost. Schlumberger drilled first well CC14 for Agip gas, 8 ½ hole section was drilled in 6.5 days where the plan was 10 days, Agip gas saved around 3.5 days of rig time, and saving 525 K on the AFE cost for this well, Fig4

![Fig4](image-url)
Value Assessment

The using of rotary steerable system will represent a significant cost for any drilling operation cost analysis of obvious importance when assessing the value a rotary steerable system can bring. Tangible timesavings can be estimated, but is equally important to review the intangible benefits such as improved coiled tubing accessibly through reduced tortuosity ot improved LWD log quality through continuous rotation and improved wellbore geometry.

Key performance indicators for rotary steerable systems should focus on total time for the hole section, the tortuosity of the profile as well as the ease of tripping, logging and running casing.

Offshore Libya. Drilling 8418 ft by PowerDrive for well CC-14 saved 8 days for Agip gas, 42% of total saving by PowerDrive, Agip gas saved 1.2 M USD, Fig5.

Also PowerDrive drilled 7760 ft and saved 10 days in well CC-05 for Agip gas, 50% of total saving by PowerDrive, Fig6, drilling until now another 6 wells completed for Agip gas by PowerDrive.

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