Rotary Steerable Performance
Mud Motor Value
Positive Displacement Motor - PDM

Cut-away of housing/stator

Rotor being installed inside newly lined stator (connection for bit box is on the left)
Rotary Drilling Technology

- Conventional Bent Sub with Mud Motors with MWD Systems
  - Directional MWD Operators – most popular system

- “Point the Bit” Rotary Steerable with flex shaft system
  - Halliburton
  - Weatherford

- “Push the Bit” Rotary Steerable with external pad system
  - Baker
  - Schlumberger

- Hybrid Conventional Bent Sub Dual Motor system
  - Roto-Slide Directional Technology
Directional Drilling - Conventional Steerable Motors

• Operation Method – Rotary and Slide Drilling

• Benefits
  • Cost effective
  • Lower dayrate $6-10,000
  • Lower Lost in Hole (LIH) cost (<$250,000)
  • Broad range of available bits

• Problems and Issues
  • Significant non-productive time required at the start of every slide to orient the toolface and to correct for drill string reactive torque
    • Directional driller corrects by rotating the top drive until downhole toolface is approximately equal to the direction he needs
    • Directional driller recalculates well path-to-plan and determines next slide interval
    • Directional surveys typically recalculate every 90 feet
    • Requires good directional driller
    • ROP reductions from 60-90% while sliding
    • Lack of pipe rotation causes the buildup of cuttings beds
    • Poor hole gauge – anomalous log responses – severe dogleg issues
    • High torque and drag on drill pipe
Directional Drilling - Rotary Steerable Systems

• Operation – Continuous Rotation

• Benefits
  • Significantly higher ROP
    • More efficient transfer of weight to the bit
    • Less chance of stuck pipe
    • Reduced torque, drag and stick-slip
  • Improved borehole quality with significantly less tortuosity
    • Better log quality (LWD or wireline)
    • Azimuthal LWD measurements provide borehole images

• Problems and Issues
  • Significantly more complex with hydraulic systems and downhole communication
    • Significantly higher day rate cost $20-35M (area dependent)
    • Significantly higher LIH cost (>1million)
    • Limited bit selection
  • Not closed loop
  • Still requires coordination of drilling rig equipment operational set points
  • Continuous rotary drilling with a downhole adjustable steering tool
  • Reduced dogleg capability
    • Necessitates an earlier (shallower) kickoff from vertical
    • Steerable mud motor often used in upper hole section
  • Less, but still significant non-productive time to transmit commands to RSS tool to set deflection and toolface
Directional Drilling – Roto-Slide Motors

Operation Method – Continuous Rotation of drill pipe while sliding

Benefits of Roto-Slide Dual Motor Technology
• Maintains high ROP without losses due to sliding
• Improved hole quality, automatic course changes as needed
• Surveys taken as necessary, without reorientation of toolface
• Simplicity of steerable mud motors
  • Priced between Conventional and Rotary Steerable Systems
  • Lower complexity
  • Lower LIH than RSS (tool capital cost)
• No non-productive time
  • No downlink required – all toolface corrections made at top drive
• Requires integration with rig VFD control systems
• Enables closed loop drilling automation system
• Completely computer driven, no driller intervention required
Typical Steerable Mud Motor

MWD Tool  Positive Displacement Mud Motor  Bent Housing  Near-Bit Stabilizer

Typical Rotary Steerable (Push to Bit or Point to Bit) Systems

MWD Tool  Sleeve Stabilizer  Non-Rotating Housing  Adjustment Pads
Eagle Ford Steerable Mud Motor vs RSS
Roto-Slide Dual Motor Technology

SLIDING MODE WITH DRILL PIPE ROTATING

Drill Pipe

Integrated MWD Tool

Bent Housing

Near-Bit Stabilizer

Counter Rotation Positive Displacement Mud Motor

Positive Displacement Mud Motor
Roto-Slide Dual Motor Technology

Drill Pipe

Counter Rotation Positive Displacement Mud Motor

Integrated MWD Tool

Bent Housing

Positive Displacement Mud Motor

Near-Bit Stabilizer

DRILLING AHEAD MODE WITH FULL ROTATION OF BOTH MOTORS
Directional Driller (DD)
- Determines whether slide or rotate drilling is required
- For slides, determines the Target Tool Face (TTF) for the slide interval (10ft, 20ft, etc).
- Monitors MWD High Side Tool Face (HSTF)
- Instructs driller to turn top drive slightly to try to get the HSTF in the vicinity of the TTF
- May have to work the pipe up/down to get top drive turn to work down to the bit.
- Once HSTF is close to TTF the DD initiates slide.
- As the bit takes weight, the HSTF will start to move clockwise and DD will have to rotate the top drive to adjust.
- DD may decide to lengthen the slide interval due to not being able to consistently hold the necessary HSTF.
- DD alternates Slide and Rotary drilling to “average out” the slide dog leg over a longer course length.
MWD Downhole RPM
MWD Highside Toolface

Actual Top Drive RPM: 79.4 RPM
Target HSTF: 45.0R

MWD Decoder

IEC Systems
Black Box

3rd Party MWD & PDM

MWD Telemetry

3rd Party Drilling Rig

Initiate Auto Drill System

Request Control TD
Give Control TD
Set TD RPM to SPRP01
Receive Actual TD RPM

Target RPM

2015 All Rights Reserved
Roto-Slide beats them all! - Why?

- Drills a straighter horizontal well better than conventional or rotary steerable systems by computer maintaining proper toolface
- Will paint the operators proposed drilling plan utilizing complex steering algorithms
- First completely automatic closed loop drilling system in the industry
- Will reduce drilling days by staying on bottom longer with less trips and longer runs
- Reduced LIH insurance
- Reduced day rate cost
- Severe reduction in torque and drag on drill pipe and running casing
- Better Cementing operation due to working pipe
- Higher production rates due to better completions and drill out operations of plugs and packers with Coil-tubing rigs

Roto-Slide will become the preferred method for Drilling Horizontal Wells!