Small Drilling Changes
Big Operational Difference

Automating surface drilling machines with downhole modelling

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Problem statement

The bottom line

• **Too high cost** per produced barrel

• **Use new technology** to increase efficiency

What happened to Shale drilling and efficiency?

*Courtesy of Stavanger Aftenbladet, May 7th*
Agenda

• Drilling inefficiency
  – Limiter #1: The human in the control loop
  – Limiter #2: Downhole vibrations (Stick slip + WOB instability)

• Proposed solution
  – Bridging the gap between surface and downhole world with modelling
Limiter #1: The human in the loop

Challenges

• Inconsistent drilling crews

• Rigs getting more advanced. More buttons to push.

• Big Crew Change. The young drillers loves hi-tech, but lacks experience

• Operators starts to care. Contractors responds.
#2 Vibrations are slowing you down!
Axial WOB and Torsional Stick slip oscillations

Customer observed vibration challenges:

• Reduced ROP. Early trips. Bits broken. MWD fails.

• Poor borehole quality. Stuck pipes. Steering issues.

• WOB instability halts operation in rough sea

• Mechanical damages top drive, pipes and downhole tools
Animation: The Race for Drilling Efficiency
Drill string is a telephone line

String length: 1919.2m
String rot speed: 85.0 rpm
SSPeaks: [0.3347] [1.0733] [1.7897] [2.5283] [3.2894] [4.0281]
EMS01Peaks: [0.3545] [1.0657] [1.7992] [2.5326] [3.2883] [4.0]

"It's a great invention, Mr. Bell, but the ringtone is sort of boring."
Controlling vibrations

![Drilling Efficiency Diagram](image)

*Courtesy of Schlumberger*
Torsional: RPM along the wellbore

- Period 7.3s
- Top Drive 92 rpm
- BHA 230 rpm
- BHA 0 rpm

Surface Top Drive 100 RPM setpoint

Test well trajectory, 7500m long

Downhole BHA/bit 0-300 RPM
Field example: Simple modelling of dRPM
SPE-170925

• Measured (magnetometer) and modelled downhole RPM

• Vertical section, 3600m MD.
Field example: Enhanced modelling of dRPM

SPE-173042
Stick-slip severity estimation

- Intuitive for Driller, 0-100%
- Metric for Remote Monitoring
- Simplified Tally input

Example:
100% severity at 100 RPM,
- Downhole $\Delta$RPM = 200 RPM
Stick and slip

- SoftSpeed On and Off example

- Curved section 8.5” Mud Motor
- 3700m MD
- 50Hz downhole sensor
- 25 minutes of drilling
Manual Drilling example (passive)

Brazil deepwater drillship. 3100 meter measured depth.

WOB: Kg

MRU Position: m

On Bottom

Peak in WOB: 25ton
Wanted WOB: 7.5ton

WOB-setpoint

Time Frame: 3min

+- 0.5 m heave
Manual Drilling example (active)

Brazil deepwater drillship. 3100 meter measured depth.

WOB: Kg

MRU Position: m

WOB setpoint

WOB peak: 11.3 ton

Wanted WOB: 7.5 ton

WOB: 0.0 ton

WOB peak: 7.7 ton

Time Frame: 3 min
Automatic Drilling with modelling

- Most auto drillers today use static tuning
- New: Axial string model auto-tunes WOB controller

= Stable WOB control. Reduced NPT. Less vibrations.

70% less WOB fluctuation!

ROP mode with passive compensation

Enhanced Active compensation ON

Using ROP mode and active compensation
Tripping consistency with Automation

MMC = Multi Machine Control

Ref SPE-168021

14.7 stands per hours to 26 with MMC

01:00 am to 03:30 am

Slips2slips time
Continuing automating the drilling process

The next step

- Multi Machine Control has demonstrated increased consistency tripping in and out pipe
- Models will improve and optimize automation of the drilling process
- Improved restricted tripping speed with surge and swab protection
Conclusion

• Three drilling efficiency technologies presented

• Downhole modelling helps to
  – Guide and optimize the human
  – Optimize Stick slip mitigation (locally/remotely)
  – Minimize WOB fluctuations

Small drilling changes will make positive impact on your drilling efficiency!
Questions?

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