MONITORING DRILLING BIT PARAMETERS ALLOWS OPTIMIZATION OF DRILLING RATES

V.C. KELESSIDIS - P. DALAMARINIS
Technical University of Crete
Mineral Resources Engineering
SGEM 2009
Albena, June 14-19, 2009
kelesidi@mred.tuc.gr
Research aim

- Optimization of drilling rates
- Less expensive and safer drilling practices
- Hydrocarbon, geothermal, mining, water well drilling
- Multitude of parameters affecting drilling performance
- Availability of data and proper modeling software
- Optimum combination ➔ better drilling rates
The problem

- Drilling allows for access to subsurface target areas
- Pythagoras saying 'whoever digs, finds, he who never digs, will never find'
- Drilling is expensive
- Optimum drilling practice → arrive to target in the most economical way, but with safety
- Main monitoring parameter - Penetration Rate (m/h)
- Depends on two main groups
  - Formation
  - Drilling parameters
Main parameters

FORMATION
- Local stresses
- Rock compaction
- Mineralogical content
- Fluid pore pressure

DRILLING
- Weight on bit and torque
- Rpm
- Hydraulic parameters
- Bit condition
Modeling drilling process - Teale

- Rock-bit interaction
- Energy to the bit
- Efficiency of energy transfer

**ENERGY PER UNIT VOLUME**

\[ SE_t = \frac{WOB}{A_{bit}} + \frac{8(RPM)(\mu D)(WOB/A_{bit})}{ROP} \]

**ROCK-BIT MODEL**

\[ UCS_{eff} = SE_t \]

\[ ROP = \frac{(8)(RPM)(\mu D)(WOB/A_{bit})}{\frac{UCS}{eff} - \frac{WOB}{A_{bit}}} \]
Payzone simulator

Developed by G. Cooper, UCB
Similar to Teale’s model predictions
Adjustable parameters
Use of historical data for tuning

ROP = (flow_factor)(C)(aggressivity)(RPM)(tooth_length)(G)

\[
G = 1 - \exp\left[ - \left( \frac{WOB}{UCS} \right)^{\text{curv}} \left( \frac{12}{D^{2.5} \left( 0.4 \times \text{tooth_length} \right)} \right) \right]
\]
Comparison of models with lab data

Bit Diam=8.5 in; UCS = 15000 psi, anhydrite

ROP (in/min)

Weight-on-Bit (klb_f)
Use of historical data

- Drilled 17 1/2" hole to 509m, logged, & set 13 3/8" casing @ 509m
- Log & set 13 3/8" casing @ 500m
- Hole deviation correction run, day rate 12th-18th
- Drilling ahead without mud motor
- Drilled 12 1/4" hole to 1755m, logged, & set 9 5/8" casing @ 1754m
- Washouts in drill pipe
- TCI bit with mud motor
- Junk in hole
- Well flowing & mud losses; LCM/barite; mw 11.2-11.5ppg
- Drilled 8 1/2" hole to 2932m, logged.
- Drilled 8 1/2" hole to 3031m, logged, plugged & suspended
- Log, P&A @ 3000m
- 031m and plugged and ended. No significant hydrocarbons in the Kapuni target. Possible updip simulation to be
Data needed

- Lithology
- Bit records and bit types
- Casing schedule
- Drilling parameters
  - WOB, RPM, FLOW RATE,
  - PRESSURE
  - ROP
- Drilling fluid
Adequate simulation
Case study analysis

- Drilling in Norwegian Continental Shelf
- Reconstruct drill time log
- 1917 - 2414 m
- Four main lithologies, 18 formation intervals

![Graph showing the relationship between real drilling time and payzone drilling time.](chart.png)
Base case and two scenarios

1. Normal drilling curve
2. Drilling curve with RPM+50 rpm
3. Drilling curve with WOB+45 kN
Full scenarios

1. Base drilling time plot
2. Simulated drilling time plot by having extra 4.5 tons, extra 50 RPM and extra 200 lpm
Increase in UCS by 50%

Increase may range between 58% and 96%, giving an overall increase in total drilling time for the sections chosen for the simulation of 82%.
Conclusions

- Penetration rate - the most sought after parameter for design of well drilling
- Attempts to simulate the process - none very successful
- Recent advances, flexible simulators that could be used on site
- Payzone, is one of them (G. Cooper)
- Drilling advance model, few adjustable parameters
- Can be tuned via use of prior historical data from the region and the field
Conclusions

- Data: WOB, RPM, Flow, well geometry, drill bit record, ROP, Lithology
- Normally monitored - need to monitor in non-critical wells also
- Can be used to effectively model and describe the drilling process
- Re-engineering and re-drilling possible, no great difficulties
- Increase in WOB, RPM, Flow → beneficial effect, need to worry about bit wear
- Increase (error) of UCS by 50% → decrease in ROP by 82%