Transient, Advanced and User-Friendly Dual Gradient simulator

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Why Simulator?

• Dual Gradient Drilling is VERY different from conventional drilling!
• Drillers, Management, Regulatory agencies etc. must understand
  – the “Pros” and “Cons”
  – the dynamical behavior.

• Design, Education & Training
• Well Control Procedures
• During drilling: Understanding the well
Model

- Dynamic two-phase flow control model developed by SINTEF
- Model presented in paper IBP1373_06 “A general dynamic model for flow related operations during drilling, completion, well control and intervention”
- General and flexible implementation
- Used for several field studies
  - MPD displacement and cementing
  - Flow test studies
  - RMR well control
- Adapted to well control operations with the CMP configuration
Feasibility evaluations

• Procedures have been developed in cooperation with oil companies
  – Drilling
  – Cementing
  – Running casing / liner
  – CMP pump failure
  – Well control

• Procedures have been verified by computer simulations
Program Output Example Results

- Dry gas influx – Constant bottom hole pressure
- CMP™ pump at 5000 ft WD
- Well depth below mud line 5000 ft
- 10 bbl influx size
Rig Pump Rate – Gas Kick

- Kick detection
- Flow reduction to circulate out kick
- Kick circulation rate high to prevent U-tubing, no U-tube arrester valve
Stand Pipe Pressure – Gas Kick

Pressure at 2000 l/m pump rate

Pressure at 1600 l/m pump rate (avoid U-tubing)
Subsea Pump Pressure – Gas Kick

Pressures In at Sub Sea Pump

- Kick passing through pump
- Increase Suction Pressure
- Subsea Ambient Pressure

Press [bar]

Time [min]

0 10 20 30 40 50 60
Gas Fraction at Subsea Pump – Gas Kick
Pit Volume – Gas Kick

Transient, dynamic PVT calculations between OBM and Reservoir fluid
Deepwater Dual Gradient Drilling System

- If we are dealing with OBM, the gas kicks (below a certain volume) will dissolve in the base oil of the mud.
- As pressure and temperature (P,T) decreases, the gas will boil out of the base oil.
- CMP have one or more sub sea pumps, this produces a discontinuous pressure profile
- Careful calculations are needed to be aware of possible problems with gas boiling out prior to sub sea pumps
Dual Gradient Drilling System

- Two pump system
- Green line:
  - "Normal" drilling
- Black line:
  - Water
- Blue line
  - CMP Mud
- Vertical line:
  - Pressure where gas "boils out" of base oil*
- Notice that gas "boils out" prior to second pump

*Just for illustration
Future work

• Adapt the Data Quality Module (DQM) to the CMP system
  • DQM will check user input and real time signals
• What-if simulation (option)
  • Standalone simulation started from the real time system
  • Accurately tuned to current situation
  • User specifies operational parameters ahead interactively through a dedicated GUI, which also shows results as graphs and numbers
• Forward-looking for CMP
  • Frequent automatic calculation to a given footage ahead, to provide accurate knowledge about what will happen if continuing as now
Questions?
Kick detection

- CMP kick detection
  - Pit gain, taking into account fluids in marine riser
  - Return flow rate: The subsea pump power consumption changes quickly with flow rate, and very early kick detection is probable
    - Large influxes will be detected long before gas reaches the subsea pump
    - Small influxes will also be detected, but some gas may pass the subsea pump before detection