Drilling depleted reservoirs

Offshore Mature Fields – Extended Life and IOR Rotvoll, 8. June 2017

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TECHNOLOGY TO SHAPE THE FUTURE OF ENERGY

Statoil’s technology strategy

INNOVATION - CROSS-DISCIPLINE SOLUTIONS - DIGITALISATION

OPTIMISE PRODUCTION FROM EXISTING AND NEAR FIELD RESOURCES

LOW CARBON SOLUTIONS FOR OIL & GAS

DISCOVER AND DEVELOP FRONTIER AND DEEP WATER AREAS

UNLOCK LOW RECOVERY RESERVOIRS

DEVELOP RENEWABLE ENERGY OPPORTUNITIES
Background

• Infill drilling important for increased oil and gas recovery

• Mature fields: non-existing or very limited drilling window

• Approximately 20 % of DPN’s IOR volumes are connected to infill drilling and depletion challenges *

• Industry challenge

* DPN IOR Strategy 2016
Well target mapping database

• Increase knowledge of future DPN well targets portfolio:

  − New technology needed to drill the targets
  − Future well design solutions needed to drill the targets in a cost effective manner
  − Potential project stoppers to be solved by future improvement projects
  − Boost IOR
Drilling depleted initiatives in Statoil

- CEO / Sætre
- DPN / Nylund
- OTE / Hove
- Advisory group
  - Drilling depleted reservoirs

- TPD / Øvrum
- R&T / Kvalheim
- R&T activities
  - Drilling depleted reservoirs
Innovation campaign

1. Cost-efficient downhole stress measurements

We are looking for solutions, methods and/or technologies which would

1) improve the existing procedures / methods to measure formation stress to enable open hole measurements
2) enable real-time - continuous or intermittent - determination of the formation stress while drilling
   a. brief interruptions of the ongoing operation to acquire measurements are acceptable
   b. here we are primarily looking for solutions which does not involve actual fracturing of the formation but where the formation stress is estimated from “log” measurements.

2. Prevention and curing of fracture related losses

We need a solution that let us quickly plug and drill ahead once a loss incident occurs. If we can fix this, the majority of our depleted reservoirs would be very drillable!

We are looking for solutions, methods and/or technologies which would

1) prevent fracture related losses
2) enable faster detection and isolation of fracture related losses
3) enable fast plugging / curing of fracture related losses
Main activities

- Secure fundamental understanding of the challenges
- Evaluate available technology to mitigate challenges
- Establish a relevant research portfolio
- Advise and support assets in re-evaluation of drilling practice and well concept
- Communicate recommendations across organization

Close collaboration

R&T

OTE
Pressure depletion

- Reduction in pore pressure as a result of producing gas and oil

- Reduction in volume -> reduction in pressure

- Pore pressure may be the initial one in shale zones

- In permeable reservoir zones, the reduced pore pressure is established almost instantaneously
Essence of challenge

- Optimize the operational drilling window
- Avoid uncontrolled risks

Is it possible to identify a “safe” operational window?
Drilling window

- Fracturing pressure
- Pore pressure
- Mud weight
- Reservoir
- Density (g/cm³)
- Depth (m)
- 30" pipe
- 20" pipe
- 13 3/8" pipe
- 9 5/8" pipe
- 7" pipe
Should be easy to solve........

YES  NO

WHY?

• Bounding curves are very uncertain
• The challenge is highly cross-disciplinary
What influences drilling in depleted reservoirs?

- Pore pressure
- Rock stresses
- Fracture pressure
- Shear failure / bore hole stability
- Loss mechanisms
- Geological complexity
- Drilling fluids
- Filter cake and well productivity
- Drilling technology
- Operational practice
- Production strategy
Pressure depletion and stress changes

Before depletion

Equivalent density

Depth

Shale

Sand

Pore pressure

Minimum horizontal stress

After depletion

Equivalent density

Depth

Shale

Sand

$\Delta p$

?
Natural losses in various formations

From: Quick reference guide BEST PRACTICE drilling operations
Drilling depleted toolbox

Methodology

Improvement projects

Existing technology

Ongoing R&T projects
Existing technology and ongoing projects

Existing technology

- Particles in drilling fluid
- Well construction
- Increased downhole knowledge and control
- Increased reservoir knowledge
- Pressure control
- Mitigate risk

Ongoing R&T projects

- Well construction
- Increased downhole knowledge and control
- Pressure control
- Decision support
- Cross disciplinary activities
Technology example - Steerable drilling liner (SDL)

- Used successfully to drill “undrillable” sections in several wells
- The SDL wells are among Statoil’s best producers drilled the last five years
- Next generation – the one trip system will be introduced 2018
Success factors

- Pore pressure
- Rock stresses
- Fracture pressure
- Shear failure / bore hole stability
- Loss mechanisms
- Geological complexity
- Drilling fluids
- Filter cake and well productivity
- Drilling technology
- Operational practice
- Production strategy
Drilling depleted reservoirs

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