Alternatives to Cased-Hole Completions in the Gulf of Mexico

Bob Holicek – Deepwater Technologies & Projects Manager, Schlumberger
Bala Gadiyar – Engineering Advisor, Schlumberger
Overview

• Why cased-hole techniques are so common in GoM
• Features of typical cased-hole completion
• Performance limitations of cased-hole completions
• Features of typical open-hole completions
• Why OH techniques are attractive and gaining consideration
• Application of OH completion techniques in 3 GoM environments
• Summary
Why Cased-Hole Completions are So Common in GoM?

• Multiple, stacked pay zones requiring isolation from each other
• Wellbore instability, case-off weak zones as soon as possible
• Low $K_v$ in turbidite/laminated formations limits production enhancement potential of openhole horizontal wells (vs. fracturing)
Features of a Typical Cased-Hole Completion

- Drilled with same mud as overburden sections (i.e. barite-weighted SBM)
- Cased & cemented
- Displace to comp. fluid
- TCP Perforated
- Run downhole tool system
  - Screens & blank
  - Fluid-loss control device
  - SC Packer/Service tool
- Pump gravel- or frac-pack treatment
- Reverse out excess slurry
- POOH, activate FLCD

- Mud not always designed to avoid formation damage
- Formation becomes sealed off
- Wellbore/reservoir connection is by way of perforated casing & cement sheath
- Hydraulic fracture to bypass near-wellbore damage
- Screen with annular gravel-pack to filter formation sand
- Perforation tunnels are not open-channels, but are instead packed with gravel
  - Source of $\Delta P$
Performance Limits of CH FP/GP

- At high $kh$, FP can have high skin, despite presence of hydraulic fracture
- High reservoir deliverability $\rightarrow$ perf tunnels choking effect more pronounced
- Also, high reservoir deliverability, more contribution from perforations that are not directly connected to the fracture (i.e. radial-flow contribution as high as 40% of total flow)
Additional Concerns

• Stacking completions across multiple zones
• Treating long-intervals, achieving full reservoir contact and complete annular gravel-packing
• Poor wellbore/fracture connection due to fracture plane misalignment

Good!  No So Good
Features of a Typical Open-Hole Completion

Prod. Casing or Liner w/ cement

Filtrate invasion

Filter-cake (temporary)

Gravel Pack

GP Screen

Native formation

Filter cake

Filtrate

Gravel
Features of a Typical Open-Hole Completion

• Drilled with dedicated reservoir drill-in fluid (RDF or “DIF”)
• Various displacement/fluid swap sequence options
  • Generally want to end up with Comp. Fluid in cased-hole above & non-screen-plugging fluid in open-hole
• Run downhole tool system
  • Screens & blank
  • Fluid-loss control device
  • SC Packer/Service tool
• Pump gravel-pack treatment, if not a standalone screen (SAS)
• Reverse out excess slurry
• Pump filter-cake breaker
• POOH, activate FLCD

• Drilling fluid specifically designed to minimize/avoid formation damage
• Formation becomes sealed off temporarily with removable filter cake
  • Dissolvable
  • Lift-off & flow-thru during production
• Reservoir connection is by way length of wellbore in zone
• Screen with annular gravel-pack to filter formation sand
• Radial pressure losses thru
  • Filtrate-invaded zone
  • Remaining filter-cake
  • Gravel-pack residual damage
Why OH Techniques Are Attractive?

• Simplicity
  – Time savings of one less casing/cementing operation
  – Fewer trips (no TCP runs, blanking plug retrievals in multiple zones)

• Productivity
  – Properly designed & executed OH completions can rival CHFP in terms of skin factor and productivity

• Necessity
  – MW window/casing program limits hole size at TD
  – Some reservoir conditions pose difficulty to fracturing
Application of OH Techniques in GOM

**WD: ~7,000’**

- Top Salt: ~11,000’
- Salt: ~5,000’
- Reservoir: ~17,000’

**WD: ~7,500’**

- Top Salt: ~15,000’
- Salt: ~8,500’
- Reservoir: ~25,000’

**WD: ~4,000’**

- Top Salt: ~15,000’
- Salt: ~8,500’
- Reservoir: ~30,000’

**Properties**

- BHT: ~125-145°F
- BHP: ~8500 psi
- Comp. Fluid: 9-10 ppg
- FG: 11-12 ppg
- Kh (md-ft): ~30-50,000
- Description: Very unconsolidated

- BHT: ~260-270°F
- BHP: ~23,000 psi
- Comp. Fluid: ~15-15.5 ppg
- FG: ~16.5 ppg
- Kh (md-ft): ~50-100,000
- Description: Sl. competent

- BHT: ~350°F
- BHP: ~17-18,000 psi
- Comp. Fluid: ~14 ppg
- FG: 15.5-16 ppg
- Kh (md-ft): ~70-100,000
- Description: Competent
Case “A”

- Zero-tolerance for sand; ruled-out SAS
- Pressure Window (FG-hyd) ~1,000-1,500 psi
  - Generally adequate for alpha-beta waterpack, but...
- Major concern: Extremely weak formation
  - Washout and filtercake erosion, HRWP is risky
  - Low-pump rate gravel placement dictates viscous carrier
  - Risk of wellbore collapse or bridge-off
- Alternate-path or “shunt-tube” design
Case “B”

• Competent rock, SC added as ‘insurance’
• Gravel-packing could be achieved with HRWP
  – Adequate pressure window
  – Low risk of filter cake erosion or washouts
  – SAS selected (low sanding risk, but also for filtercake removal concerns if gravel-packed)
• Very high temperature limits options for RDF
  – Usual components of polymers & starches...
    • Those that hold-up at temperature are hard to break
  – Considered use of high-solids-content DIF (i.e. insolubles)
  – Developed WB DIF using synthetic polymer & breaker
  – Filtercake cleanup by way of flow thru screen & breaker action
Case “C”

- Consolidated rock, however depletion plan likely to lead to later-life sanding, GP preferred over SAS
- Deviated, but not horizontal wells, gravel placement by water packing (non-alpha-beta, not as much limited by pressure window)
- High completion fluid density (>15 ppg) and use of ZnBr$_2$ limits fluid options
  - Potential adverse reactions between DIF components and Zinc
  - CaBr$_2$ based system avoids incompatibilities, gives good clean-up,
Summary

• When Cased-hole frac-pack techniques have reached their limits...

• OH completion techniques can be viable, even in most-challenging conditions
  – Correct application selection
  – Proper design and planning
  – RDF selection and clean-up methodology
  – Displacement sequence/wellbore preparation
  – Execution
Additional Info

