DEA Forum

PDC Bit Innovations for Today’s Complex Shale Wells

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Overview

• Complex well profiles require more complex BHA
  – More “jewelry” in the BHA

• Variety of new motors available
  – Higher torque
  – Longer life

• Rotary Steerable Systems
  – Bits designed for the system

• Limited HSi at the bit
  – Design and plan for it

• More demands on the cutters and bits
  – Stability improved
  – Steerability (DOC Control)
  – Durability and abrasion resistance improvements in cutters

• PDC Cutter is part of the bit, which is part of the system.
Steerable Bit Technology Package for Unconventionals

- Unconventional shale formations
- Curve-lateral sections
- Low HSi
- Features:
  - Application specific profile
  - Polished cutters
  - Application specific cutters
  - Diverging junk slots
  - Hydrophobic coating (available on request)
  - Advanced hardfacing on tough steel body
  - Short bit body
  - DOC control to minimize torque fluctuations
    - Field adjustable available soon
  - DART process

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Cutter Technology Innovations

- Improved thermal stability
- Polished finish to reduce friction
- Multidimensional contoured face runs cooler
- Enhanced chamfers to improve durability
- Higher diamond density tables
- Stronger diamond to diamond bonding
- Innovative PDC manufacturing processes
- Proprietary diamond mixes to control crack propagation
- Enhanced substrate for erosion resistance
- Rotating cutter
- Shaped cutters
- Nano-technology
- Non-metallic binders, reattached, brazed, etc.
Lateral section, Bakken, 6” 6 blades

• Features
  – Short profile
  – Longer gage length
  – Variable back-rakes
  – DOC features as required
  – Large blade standoff
  – Open hydraulically

• Results
  – Drilled the entire lateral
  – Typically requires 2-3 bits to reach a similar depth
  – Saved the customer trip time and bit cost
  – 9,685' in 101.5 hours for an average ROP of 95.4 ft/hr.
  – Reduced the section versus the closest offset by 40 hours
  – Saved the operator $133,000.
Laboratory Test

- Dual Chamfer Geometry significantly adds cutter life
- Increase in Secondary Chamfer size increases cutter life
6.125” Standard Vs Dual Chamfer Cutters

Bit #1
DPD406X
1726’ @ 46.6 ft/hr

Alfalfa, Oklahoma

Bit #2
DPD406X DUAL CHAMFER
2438’ @ 55.7 ft/hr
8.75” Same Pad – Standard vs. Dual Chamfer

Bit #1
DPD505
3273’ @ 73.6 ft/hr

Bit #2
DPD505 Dual Chamfer
5105’ @ 74.5 ft/hr

Saginaw, Texas
Multidimensional Contoured Face

Longer, faster, and good dull in a very hard abrasive application
Multidimensional Contoured Face
Permian Case Study #1 – CO₂ Injection Wells

The Challenge
- Yoakum County, TX
- San Andres Formation
  - Hard dolomites, anhydrites, and salts
- Drill curve and entire lateral with one bit

The Solution
- State of the Art PDC Bit
  - Polished Cutters
  - Application Specific Cutter Technology
  - Steel body with new Hardfacing
  - Enhanced Directional Control
The Results

- Back to back record runs
- Exceptional tool face control
- Saved 2 days on well
- Great dull condition

Note: 2 runs, near identical
Case Study #2 – Wolfcamp B Horizontal

The Challenge

• Reagan County, TX
• Wolfcamp B Formation
  – Shale, sandstone, chert
• Drill 9,500ft lateral with one bit
• Conventional motor assembly

The Solution

• State of the Art PDC Bit
  – Polished Cutters
  – Enhanced Cutter Technology
  – Steel body with new Hardfacing
  – Enhanced Directional Control
The Results

- Drill 9,500ft at 98ft/hr
  - Offsets typically drill interval with multiple bits
- Saved operator 4 days drilling time
- Excellent steerability
Eagleford Vertical-Curve-Lateral 1 bit run

**Challenge**
- Complete V-C-L in ONE bit run
- Drill each section with increased ROP
- Maintain exceptional toolface control in the curve section

**Results**
- Went in at 5,200' and drilled to TD at 16,905' in 107 hours;
- ROP of 109 ft/hr.
- Saved the customer 78.7 hours compared to the offset average and approximately $139,000!

**Impact**
- 1 bit under surface to TD is not an item on your Christmas list any more but a real possibility! Work with your bit engineer to choose the right features and operating parameters.
Eagleford Vertical-Curve-Lateral, 1 bit run

• Challenges
  – Drill the entire Vertical-Curve-Lateral with a conventional assembly from surface casing in one run with one bit and BHA
  – Drill vertical section at increased ROP
  – Maintain tool face control in the curve to achieve build rates
  – Improved tracking ability in the lateral to reduce slide time

• Results
  – Completed the Vertical-Curve-Lateral section 20 times, YTD 2014
  – There has NOT been one DBR'd bit out of the 20 completed runs
  – Dull grades typical 11TD to 12TD
# Eagleford Vertical-Curve-Lateral, 1 bit run

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Hybrid Bits Case Study in Unconventionals

• The Challenge: Wolfecamp curve
  – Complete curve in one run
  – Maintain or improve wear, durability, dull condition over PDC.
  – Drill through conglomerate, chert, sand

• The results
  – Beat offsets solidly
  – Run of 38.8 fph vs. 18.0 fph
  – Maintained targeted build rate of 14° or higher per hundred
  – One run curve in typical “2” bit section
  – 1,1 Dull
  – Saved 18 hours vs. offset average
Hybrid Performance in Curve

Case Study: 8¾-in. Kymera (Reeves County)
Depth In/Depth Out vs. ROP

Offsets (Average)

Kymera FSR
Hybrid FSR vs. 7 blade
- Bone Springs, Permian

Problem drilling curve:
- Bone Springs Permian
- Challenging Carbonates
- Multiple bits building 12°/100ft
- Limited WOB with PDC due to reactive torque

Solution:
- 8-3/4” Hybrid in 1 bit
- Smooth drilling
- Increased ROP due to reduced reactive torque

Increased ROP by up to 2x in carbonates

Case Study: Hybrid Technology in South Texas

Hybrid vs. 5 - 6 blades
- Eagle Ford, South Texas

“125 ft/hr from Hybrid is the fastest I've seen through a curve on this pad”
Directional Driller for Eagle Ford

Problem drilling curve:
- Karnes county, Eagle Ford
- Multiple bits curves & DTF
- Limited WOB with PDC due to reactive torque

Solution:
- Hybrid up to 125ft/hr
- Maintain steerability and allowed to maximize speed
- Set operator record for Eagle Ford

Consistency and speed, saves $510k in 3 wells
Case Study: Hybrid curve in Mid-continent

Challenge:
- Complete curve in 1 run
- Improve ROP, footage, customer economics
- Maintain tool face control
- Reduce number of bits and trips

Results
- Hybrid 674’ at 13.2 fph
- PDC 356’ at 7.9 fph
- Faster, longer runs
- Less bits
- Improved economics
- Happy customer
Summary

• Innovations in the PDC cutter and PDC bit have greatly improved economics of horizontal unconventional wells.
• One PDC bit can generally complete the lateral.
• The focus shifted to the vertical and build sections.
• One section bit runs are becoming the norm.
• Hybrid bit technology is becoming a standard curve choice in more demanding applications.
• One bit to TD is a realistic objective in many applications. One bit V-C-L is in sight for more applications.
  – Bit specialist and drilling engineer collaboration.
• Today’s PDC cutter is substantially improved over decade.
• Cutter and bit innovations have lead to field records.
• Innovation is alive and well in our industry.
Future Possibilities (Survey of US Patents)

• Real time data from the bit
  – Module in the bit shank with monitoring and measuring capabilities
  – Optimize parameters
  – Maximum performance

• Sensors and monitors in the bit
  – Performance
  – Response
  – Formations
  – Integral part of the automated drilling system

• Bit as part of an adaptive system

• Innovative cutter shapes

• Innovative diamond tables

• Smart PDC cutters
Thank the DEA for this opportunity to share results of recent innovations.

Thank you for your attention.