Alcoa Oil & Gas, Inc.

IADC --DEC Technology Forum
Jeffry Lehner, Technology GM
09/15/2014
Extending the Reach—with FarReach Drill Pipe Yields Significant Cost Savings

- Alcoa Oil & Gas, Inc.
- Directional Mud Motor
- Vertical Rigs
Alcoa at a glance

- Founded in 1888
- 200+ locations in 31 countries
- $25B in 2013 revenue
- Invented the Modern Aluminum Industry
- *Fortune* magazine’s #1 “Most Admired” metals company
- 125 years of metallics technical leadership including the original aluminum process
- Alcoa has invented 95% of the aluminum alloys that are in flight today

**Number of Employees (2013)**

<table>
<thead>
<tr>
<th>Region</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>26,000</td>
</tr>
<tr>
<td>Europe</td>
<td>17,000</td>
</tr>
<tr>
<td>Other Americas</td>
<td>11,000</td>
</tr>
<tr>
<td>Pacific</td>
<td>7,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>61,000</strong></td>
</tr>
</tbody>
</table>
Alcoa Oil and Gas (AOG) business unit

- Located in The Woodlands, TX (North of Houston)
- Independent business unit of Alcoa
  - A division of Alcoa Engineered Products and Solutions
- Cross functional team
  - Metals & O&G industries
  - Manufacturing, quality, technology
- Mission to grow oil and gas market for aluminum alloy solutions and sub systems
  - Riser
  - Drill pipe
  - Casing
  - Forgings, casting, tubing, sheet & plate
Targeted O&G Investment in R&D

- Alloy Development
  - Leveraging aerospace
  - Microstructure-process-performance
- Corrosion
  - Seawater & CP System
  - Internal fluids
- Coatings
  - Corrosion mitigation
  - Wear
- Design, Analysis & Testing
  - Drill Pipe
  - Mechanical Connections
- Manufacturing
  - Fusion & Solid State Welding

$10m+ Investment
Benefits with Directional Mud Motors

• Why Using Aluminum DP?
• Torque & Drag Basics
  – Friction & Contact Forces
  – Weight / Buoyancy
  – Stiffness
• Case Study
• BHA & Drillstring Design
• Results
• Conclusion

Ryan Directional and Alcoa Oil & Gas
Why Using Aluminum DP?

• **Problematic**

  Torque & Drag & Buckling is a concern in long horizontal wells because of cumulative **Friction Forces** that lead to

  • Excessive Torque
  • Compression & Buckling (poor WOB Transfer in sliding mode)
  • Limitation of the lateral extension of the well

• **Solution**

  Reducing **Friction Forces** with light weight Aluminum DP
Friction Force = $\mu \cdot$ Normal Force

$\mu = \text{Coefficient of friction}$

Reduction of Friction Forces with Aluminum DP due to lighter weight
### Torque & Drag Basics

**Weight & Buoyancy**

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Density</th>
<th>Weight in Air (lb/ft)</th>
<th>Weight in 10 ppg Mud (lb/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 7/8 in. Aluminum DP</td>
<td>2.80</td>
<td>16.6</td>
<td>9.5</td>
</tr>
<tr>
<td>5 in. Steel DP</td>
<td>7.85</td>
<td>23.6</td>
<td>20.0</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>-30%</strong></td>
<td><strong>-52%</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Reduced Weight & Higher Buoyancy**
As bending Stress is lower with Aluminum DP, the contribution of stiffness to normal force is reduced, leading due a reduction of Torque & Drag.
Torque & Drag Basics
Aluminum DP

Reduced Stiffness
+ Lighter Material
+ Higher Buoyancy

= Less Torque & Drag
Better WOB transfer (Higher ROP)
Case Study in Shale Play

SPE170255 • Successful Use of Mixed Aluminum-Steel Drill Pipe String In Complex Horizontal Wells: Case Study • Stephane Menand
### Comparison between Mixed SDP-ADP string and SDP String

<table>
<thead>
<tr>
<th>Parameter</th>
<th>5” Steel SDP</th>
<th>5 7/8” ADP</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD (in.)</td>
<td>5</td>
<td>5.743</td>
</tr>
<tr>
<td>ID (in.)</td>
<td>4.28</td>
<td>4.68</td>
</tr>
<tr>
<td>ID Tool Joint (in.)</td>
<td>3 ¾</td>
<td>4.68</td>
</tr>
<tr>
<td>OD Tool Joint (in.)</td>
<td>6 5/8</td>
<td>7 3/8</td>
</tr>
<tr>
<td>Wear Pad OD (in.)</td>
<td>-</td>
<td>6 1/8</td>
</tr>
<tr>
<td>Grade</td>
<td>S135</td>
<td>2014-T6</td>
</tr>
<tr>
<td>Make up torque (ft.lbs)</td>
<td>38,044</td>
<td>51,100</td>
</tr>
<tr>
<td>Tensile Yield (klbs)</td>
<td>712.0</td>
<td>505.0</td>
</tr>
<tr>
<td>Torsional Yield (klbs)</td>
<td>74,100</td>
<td>58,000</td>
</tr>
<tr>
<td>Linear Mass (lb/ft)</td>
<td>23.40</td>
<td>16.60</td>
</tr>
</tbody>
</table>

180 joints of ADP (~ 30% of the total length)

**Comparison between Mixed SDP-ADP string and SDP String**

**Same** PDC bit - **Same** BHA (Steerable Mud Motor)
Case Study in Shale Play

Well 1
Steel DP String

Well 2, 3, 4
Mixed Steel & Aluminum DP

Lateral length = ~ 6,000 – 6,500 ft

Target Line: 10,702 TVD @ 0° VS with 3.5° Up-dip

SPE170255 • Successful Use of Mixed Aluminum-Steel Drill Pipe String In Complex Horizontal Wells: Case Study • Stephane Menand
Results
Torque off Bottom

Mean Torque Reduction = 25%
Results

Hook Load While Sliding

Real WOB while sliding in the lateral section section = 5-10 klbs
Results

Hook Load While Sliding

Real WOB while sliding in the lateral section section = 15-20 klbs
Mean ROP increase = +43% (sliding) + 8% (rotary)
Conclusion

• Successful Use of Mixed ADP-SDP String In Complex Horizontal Wells

• Field results and simulations show that:
  – Torque was reduced by 25%
  – WOB transfer was better (about +10 klbs at the bit) while sliding
  – ROP was increased by 43%
Conclusion

ADP associated with a steerable mud motor could be an economically and technically viable solution to compete with RSS in shale gas plays.
The Problem: Can’t Achieve your Goal without a Bigger Rig

- You need to drill farther to reach your goal…

- The traditional answer….bring in or create a bigger rig (if you can). The Result….

- Your costs rise rapidly…
  - Capital
  - Operating Costs

- Your footprint increases…
  - Permitting fees go up
  - More land space
  - More impact on roads, environment
  - Transport costs rise
  - More energy costs
  - Larger crews
What if… the answer was not a bigger rig?

What if:

- You could use the same rig that you are currently but reach 30%-40% farther?
- You could go to a smaller rig and achieve the same as the big rig?
- You can’t bring in a bigger rig but, using the existing rig, could now achieve your goal?

If you could, you would:

- Save Money
- Save Time
- Lower your environmental footprint
- Produce hydrocarbons previously not accessible
The Cost of THE BIGGER RIG
Q2 2010 US Land

% Increase in Rig Cost
750 HP Rig -> 1500 HP Rig

- Midcon: 45%
- ArkLaTex: 49%
- Gulf Coast: 36%
- Permian: 40%
- Rockies: 54%
- STX: 69%

Example:
- +$75000 additional cost - 10 Day Well using a larger rig in South Texas:

*The Land Rig Newsletter “Day Rate Report”, 2Q 2010, Volume 20, Number 2
**Case Study: Eclipse Vertical Air Drilling**

**Rig:** Schramm T200XD Carrier Mounted Rig  
**Hookload:** 200,000#  
**Limitation:**  
- BHA & 4.5” SDP 19.5#/ft,  
- Typically 5800’ in straight vertical  
- Hookload was maxed out  
- 15 degree angle  
**Objective:** Drill to 6410’  
**Solution:** 3100’ of 4.5” steel pipe and adding 3300’ aluminum drill pipe  
**Benefits:**  
- Reached TD of 6410’  
- Achieved 50,000’ overpull margin  
- Half from weight reduction of pipe  
- Half from reduced side load in deviated well  
- $150,000 cost savings per well
**Conclusion**

- Significant opportunities to save money
- Rapidly gaining acceptance

**Contact:**
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- Abdias Alcantara
  - Business Development
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Optimized tube geometry
- Tapered upset tube
- Strength-to-weight
- Mechanical processing
- Range 2/3 (long length)

Connection you can trust
- Thermal/interference fit
- Pressure tight 5000 psi
- Proven in the field 30+ yrs
- Reynolds/Reed/Baker lineage

Proven Alloy/Temper
- T6 Peak strength temper
- 2014 High strength 58 YTS
- Good corrosion resistance
- Good fatigue resistance
- Reynolds lineage

<table>
<thead>
<tr>
<th>Strength Properties of 2014 Aluminum Alloy Drill Pipe</th>
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<tbody>
<tr>
<td>Tensile Strength, minimum psi.</td>
</tr>
<tr>
<td>Yield Strength, minimum psi.</td>
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</table>
AADP can reduced tendency to buckling

In mixed string deployment the reduced weight & torque of AADP compliments steel pipe to reduce buckling tendency.
ADP Outperforms SDP in Fatigue!

**Steel**

Percentage Fatigue Life Expended in a 30 Foot Interval

Fatigue Damage of 4-1/2" Grade E drill pipe in gradual dog-legs (non-corrosive environment: Rotary Speed, 100 RPM; drilling rate 10 ft./hr.; and mud, 10 lb./gal.)*

**Aluminum Alloy**

Percent Fatigue Life 2014 Expended in a 30 Foot Interval

Fatigue Damage of 4-1/2" aluminum drill pipe in gradual dog-legs (Rotary speed, 100 RPM; drilling rate 10 ft./hr.; and mud, 10 lb./gal.)*

STOS—Shell Todd New Zealand—completed ERD well from work over rig, extending reach of rig, 3435’ added length, 30% less torque, drilled December 2013

Eclipse—Ohio, extended vertical drilling reach of Schramm 200 rig by 3000’, enabling lower cost rig to complete vertical section. Hook load reduction up to 50%

Penn Virginia—Eagle Ford shale in south Texas. 30% improved ROP enabling use of lower cost mud motor directional steering as opposed to 3X more expensive RSS. May 2014

Maersk—work over of 28,000’ lateral, allowed extension of re-entry of uncased laterals, cementing and abandonment, allowing new parallel well to be drilled, and improving productive capacity of field. May 2014

Fugro McClelland GeoSciences – Drill pipe, Offshore Brazil, Gulf of Mexico: Produced 6,000 ft of pipe for use in offshore survey work. Depths of 8,000 to 10,000 ft. Fugro has existing Alcoa (Reynolds design) pipe with up to 20 year of service.