Hollow Sucker Rods: Development and applications in Beam Pumping

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TENARIS
Agenda

• Hollow Rod development
• Operation Challenges
• Applications
• Conclusion
“Pumping Through Macaroni* (Hollow) Sucker Rods” George McDANNOLD. SWSC 1960
Main Characteristics

- Produced from seamless pipes with box-box ends and nipple connectors.
- Torque based + displacement Make-Up, no special tools required, only conventional rig tooling.
- Flush Connection (reduces wear failures in tubing).
- Possibility to inject through the hollow space.
- Available in Corrosion Resistant Steels
Lab testing on full scale for BP

<table>
<thead>
<tr>
<th>Variable</th>
<th>Amount</th>
<th>Unit</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burst</td>
<td>32240</td>
<td>psi</td>
<td>Simulated with OCTG R&amp;D simulators</td>
</tr>
<tr>
<td>Collapse</td>
<td>31990</td>
<td>psi</td>
<td>Simulated with OCTG R&amp;D simulators</td>
</tr>
<tr>
<td>Sealability (N2)</td>
<td>15000</td>
<td>psi</td>
<td>+20Tn Axial load and at room temperature and 150C. N2 Gas was used</td>
</tr>
<tr>
<td>Fatigue endurance limit</td>
<td>180</td>
<td>MPa</td>
<td>This value corresponds to a load range of 100% MGD of an UHS 1” sucker rod.</td>
</tr>
</tbody>
</table>

\[
T_{S_{allow}} = \left( \frac{UTS}{2.8 + 0.375 \times T_{S_{min}}} \right) \times SF
\]

\[
\% Good man = \left( \frac{T_{S_{max}} - T_{S_{min}}}{T_{S_{allow}} - T_{S_{min}}} \right) \times 100
\]

\[
T_{S_{allow}} = \text{Allowable tensile strength}
\]
\[
T_{S_{min}} = \text{Minimum tensile strength}
\]
\[
T_{S_{max}} = \text{Maximum tensile strength}
\]
Operation Challenges

Flow Assurance
- Paraffin/Asphaltenes
- High viscosity fluids

Hole deviation
- High wear rate along the tubing string
- High wear rate on the top of the pump

Corrosion
Does not allow high strength steel grades usually required for high loads

Slim Hole Completions
Rod size limited by the tubing and casing ID

Common failures
Applications: Injection

- Pumping while treating through the annulus.
- Batch or continuous treatment Optimization.
- Hot oil/water or steam assisted stimulations.
Applications: Injection

Case 1
- ALS: Beam Pumping
- Depth: 2725 ft
- Tubing: 2 7/8”
- Pump Size: 1 ¾”
- Pumping unit: C-303-200-118
- Fluid Rate: 195 bbl @80% Ef
- String Design: 100% Hollorod™

Paraffin Treatment:
- 1st Stage: continuously injection with 25 % chemical & 75 % solvent.
- 2nd Stage: Steam injection
## Applications: Injection

*Comparison based on standard operation regime, not considering the initial installation.*

<table>
<thead>
<tr>
<th>Treatment Method</th>
<th>Risk of formation Damage</th>
<th>Production Stop Required</th>
<th>Rig intervention Required</th>
<th>Heat transfer Efficiency</th>
<th>Inhibition Efficiency</th>
<th>Rig Cost/Others</th>
<th>DLS Restrictions</th>
<th>Chemical Waste Risk</th>
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</thead>
<tbody>
<tr>
<td>CSG-TBG Annulus Batch</td>
<td>High</td>
<td>No</td>
<td>No</td>
<td>Low</td>
<td>Low</td>
<td>Yes</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>CSG-TBG Annulus Continuous</td>
<td>High</td>
<td>No</td>
<td>No</td>
<td>Low</td>
<td>Low</td>
<td>No</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>Re-Circulating</td>
<td>High</td>
<td>Yes</td>
<td>Yes</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>No</td>
<td>High</td>
</tr>
<tr>
<td>Capillary String</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>N/A</td>
<td>High</td>
<td>High</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>HolloRod™</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>No</td>
<td>Low</td>
</tr>
</tbody>
</table>
Applications: High Deviation Target

- Tubing wear failures in high dog leg severity sections of a well.
- Combined string with conventional sucker rods.

Flush Design

Improved Fatigue Resistance

Conventional tooling
Applications: High Deviation Target

Well AB1
- ALS: Beam Pumping
- Depth: 2970 ft
- Tubing: 2 7/8”
- Pump Size: 1.5”
- Fluid Rate: 274 BPD
- String Design: 2970 ft HolloRod®
- Run life: 1504 days w/ HolloRod® (re-design)

Well AB2
- ALS: Beam Pumping
- Depth: 2750 ft
- Tubing: 3 ½”
- Pump Size: 2.75”
- Fluid Rate: 1422 BPD
- String Design: 2750 ft HolloRod™
- Run life: 698 days w/ HolloRod™ (pump failure)
- Average RL before HR: 318 days
  (Conventional Sucker Rod: body break)
### Applications: High Deviation Target

<table>
<thead>
<tr>
<th>Well#</th>
<th>ALS Type</th>
<th>Number Make-ups</th>
<th>Installation Date</th>
<th>Max Run Life</th>
<th>Run Life Range</th>
<th># HolloRodsTM installed</th>
<th># Conventional Rods</th>
<th>% HR/API</th>
<th>Tubing Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BP</td>
<td>1</td>
<td>1/26/2011</td>
<td>1492</td>
<td>540+</td>
<td>76</td>
<td>20</td>
<td>79%</td>
<td>3 1/2&quot;</td>
</tr>
<tr>
<td>2</td>
<td>BP</td>
<td>2</td>
<td>7/23/2011</td>
<td>1314</td>
<td>540+</td>
<td>69</td>
<td>28</td>
<td>71%</td>
<td>3 1/2&quot;</td>
</tr>
<tr>
<td>3</td>
<td>BP</td>
<td>1</td>
<td>1/16/2011</td>
<td>1502</td>
<td>540+</td>
<td>93</td>
<td>0</td>
<td>100%</td>
<td>3 1/2&quot;</td>
</tr>
<tr>
<td>4</td>
<td>BP</td>
<td>1</td>
<td>1/5/2012</td>
<td>1148</td>
<td>540+</td>
<td>34</td>
<td>92</td>
<td>27%</td>
<td>3 1/2&quot; TK</td>
</tr>
<tr>
<td>5</td>
<td>BP</td>
<td>1</td>
<td>12/18/2010</td>
<td>1531</td>
<td>540+</td>
<td>64</td>
<td>0</td>
<td>100%</td>
<td>3 1/2&quot;</td>
</tr>
<tr>
<td>6</td>
<td>BP</td>
<td>2</td>
<td>8/3/2011</td>
<td>1303</td>
<td>540+</td>
<td>91</td>
<td>0</td>
<td>100%</td>
<td>2 7/8&quot;</td>
</tr>
</tbody>
</table>

#### Operational conditions:
- The pump depth is the 3000-3200 ft, the average production is 670 bpd. Some wells produced over 1000 bpd.
- The tubing in general is 3.5”, in a few cases is 2 7/8”.
- The dogleg value between 2 to 5°/100 ft and we have CO2 in these wells.
- Water: 60-90%
- Sand: 5% approx
Applications: Tubing Less

- Target to slim hole wells
- Allows the use of bigger insert pumps as the diameter restrictions will be delimited by the casing.
Applications: Flush Sinker Bars

- Target to high dog leg severity zones on the top of the rod pump.
- Reduces bucking tendency
- It can be combined with internally coated tubing around the zone.

Flush Design + Stiffness + Weight
Applications: Flush Sinker Bars

- This is the previous history for one of the test wells, actually is still running with 9 months operation.

- Two wells have been installed with polylined tubing to increase repeated tubing wear failures.
Conclusions

**Flow Assurance**
- ✔ Increases efficiency of current treatments.
- ✔ Targets the interested zone.

**Hole deviation**
- ✔ Improves run life in wells with high dogleg and reduces buckling tendency

**Slim Hole Completions**
- ✔ It gives a reliable alternative to tubing + rods completion.

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**Injection**

**High deviation target**

**Sinker Bar Application**

**Tubing Less**
Questions

- Rodrigo Ruiz – Technical Sales Manager
- Gustavo Alvarez – Technical Sales Engineer
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