Technical Limits and Challenges for Mud Motors Today

Tuesday, November 10th, 2015

By: Dr. Gunther (doc)
Agenda

- Mud Motors are used to...
- Evolution – Trends over the last years
- Challenges in 2015
  - Drilling
  - Motor
- What really happened?
- Limits and potential New Directions
Mud Motors are used to...

<table>
<thead>
<tr>
<th>Turn</th>
<th>Steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️ A bit or mill</td>
<td>✔️ A bit or mill</td>
</tr>
<tr>
<td>✔️ A Rotary Steerable System or a Steerable Bit</td>
<td></td>
</tr>
<tr>
<td>✔️ Fishing tools</td>
<td></td>
</tr>
<tr>
<td>✔️ Coring tools</td>
<td></td>
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<tr>
<td>✔️ Casing cutting tools</td>
<td></td>
</tr>
</tbody>
</table>
## Evolution – Trends over the Years

<table>
<thead>
<tr>
<th>Issues</th>
<th>Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. MWD Batteries</strong> - lasted too few hours</td>
<td>• Now at 200 hours</td>
</tr>
<tr>
<td><strong>2. Bit wear</strong> - too high</td>
<td>• Now with long lasting and aggressive PDC</td>
</tr>
<tr>
<td><strong>3. Power Sections</strong> - too weak</td>
<td>• Now with hard rubber and Even Wall / ERT</td>
</tr>
<tr>
<td><strong>4. Bearing Sections and Transmissions</strong> - too weak</td>
<td>• Still need to fix it for more Horsepower and SBTB</td>
</tr>
</tbody>
</table>
Evolution of Mud Motors

All numbers are estimates made by the author.
# Drilling Challenges in 2015

## Increase ROP

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal:</td>
<td>25 FPH</td>
<td>-</td>
<td>120 FPH</td>
</tr>
<tr>
<td>Motor runs:</td>
<td>80 hrs</td>
<td>-</td>
<td>200-300 hrs</td>
</tr>
<tr>
<td>Days per well:</td>
<td>-</td>
<td>20 days</td>
<td>8 days</td>
</tr>
<tr>
<td>BHA for curve &amp; lateral:</td>
<td>multiple</td>
<td>-</td>
<td>generally 1</td>
</tr>
</tbody>
</table>

## Reduce Cost

- Reduce cost per well drilled by **30%** over the last two years
  - Oil companies more and more refuse to pay for motor repair charges
  - Motor charges per hour dropped almost 40% in 16 months
## Motor Challenges in 2015

### Increase of horsepower

- Increase of horsepower to the bit, hence more torque and more flow available **to the Limits**

<table>
<thead>
<tr>
<th>Maximum Torque FT-LB</th>
<th>1995</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-3/4&quot; (5&quot;)</td>
<td>1,500 - 2,000</td>
<td>5,000 - 8,000</td>
<td>16,000</td>
</tr>
<tr>
<td>6-3/4&quot; (7&quot;)</td>
<td>4,000 - 7,000</td>
<td>12,000 - 24,000</td>
<td>45,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum Flow GPM</th>
<th>1995</th>
<th>2015</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-3/4&quot; (5&quot;)</td>
<td>250</td>
<td>350</td>
<td>400</td>
</tr>
<tr>
<td>6-3/4&quot; (7&quot;)</td>
<td>600</td>
<td>720</td>
<td>800</td>
</tr>
</tbody>
</table>
## Motor Challenges in 2015

### 2. Bit to Bent
- Reduce the bit to bent length from an average of 74” - 76” to 54” - 56”
  - So, limited utilization of a single flex shaft as transmission
- Ultra Short 23” - 32”

### 3. Max Angle
- Maximum angle setting while rotating
  - 2005: 1.5°
  - 2015: 2.38° (2.60°)

### 4. Max RMP
- Maximum RPM of motor
  - 2005: 20 - 40 RPM
  - 2015: 120 RPM
What really happened?

- Longer lasting and more aggressive bits
- More hydraulic horsepower on the rig (pressure went from 3,200 psi up to 7,500 psi)
- Much more efficient Moineau power section

• Therefore **two to three times** more horsepower to the bit
• **Mechanical challenge** for transmission and bearing section
Technical Limits

• Mud Motors are close to their technical limits to
  ▪ Transmit the mechanical horsepower to the bit
  ▪ To keep the well cleaned but prevent erosion
  ▪ To run the motor economically (manage motor wear) for the service and motor companies
New Directions

Tracking of Hours
- Tracking of run-hours with a smart chip to optimize part utilization (fatigue)

High Flow Rates
- By passing of mud flow above the motor
- Reduce circulating time

Drilling
- Near bit MWD Technology, reducing sliding mode from ~20% to ~10%
- Stabilization of motors
- Smart steering decision to optimize sliding

New Materials
- Yield of material changed already from 120ksi to 165 ksi hence there is not much more “room”

New Designs
- One-way motor (disposable)
- Percussion Drilling to reduce torque
- High speed drilling with a minimum of 800 RPM
Thank You

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