Hollow-Glass Spheres Application in Drilling Fluids: Case Study

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Outline

- Introduction: hollow glass spheres (HGS) in drilling
- HGS trial: horizontal section
- HGS trial: vertical section
  - Reference Well A
  - Wells B and C with HGS
- Well performance analysis
- Conclusions
- Closing/discussion
HGS in Drilling

Description

- Engineered material with consistent properties
- Unicellular hollow spheres composed of soda-lime borosilicate glass
- Density reducing additive
HGS in Drilling

Properties

<table>
<thead>
<tr>
<th>Product</th>
<th>Typical true density (g/cc) (^1)</th>
<th>Particle size (microns, (D_{50}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGS4000</td>
<td>0.38</td>
<td>40</td>
</tr>
<tr>
<td>HGS5000</td>
<td>0.38</td>
<td>40</td>
</tr>
<tr>
<td>HGS8000X</td>
<td>0.42</td>
<td>26</td>
</tr>
</tbody>
</table>

\(^1\): Density measured at atmospheric pressure

Survival curves for HGS4000, HGS5000, and HGS8000X at different pressures

Isostatic Pressure (psi)

- HGS8000X
- HGS5000
- HGS4000
Montney formation—NW Alberta, Canada

Objective: ROP increase in the horizontal section

HGS8000X at 9 to 11% V/V used in base oil

HGS kept in suspension in low viscosity fluid

Economic benefits not attained

Lessons learned integrated on next trial

- HGS mixing system optimization required
- Rig fluid tanks agitation necessary
- Optimize centrifuge configuration
Severe loses from surface case shoe to Cardium Fm.
- 600 to 2,361 m true vertical depth (TVD)

Total loss of circulation at 858 m

Several lost circulation pills pumped over three days

2,305 to 2,361 m losses deemed “acceptable”

Total of 34.25 hours of nonproductive time (NPT) and 537 m³ invert emulsion fluid (IEF) lost

Second intermediate section drilled without significant losses
ECD at 1.5 m³/min

Increased pump rate lowered equivalent circulating density (ECD) because of the decreased cuttings load

ECD at 3.0 m³/min
Reference Well A: Learnings

1.6 m³/min Minimum flow rate necessary for adequate hole cleaning
HGS Trial: Vertical Section—Well B

- Objective: reduce losses and NPT
- 60% chance of lost circulation—offset data
- Managed pressure drilling through the problem section using HGS in IEF
- HGS4000 and HGS5000 used
HGS Trial: Vertical Section—Well B

- Mixing equipment and handling
  - Double diaphragm pump used
  - Basic PPE (no respirator required)
  - Fluid tanks agitation

- Solids control
  - 170 mesh shaker screens (88 μm) — recovery of HGS (40 μm)
  - Two fully variable speed 13.9 inch bowl diameter centrifuge with backdrive (450 - 600 lpm)
HGS Trial: Vertical Section—Well B

- Low gravity solids (LGS) monitoring
  - LGS concentration estimated by combining material and volume balance equations

\[ V_{\text{LGS}} = \frac{V_F (D_F - D_{\text{BF}}) + V_{\text{HGS}} \phi_{\text{HGS}} (D_{\text{BF}} - D_{\text{HGS}})}{\phi_{\text{LGS}} (D_{\text{LGS}} - D_{\text{BF}})} \]
HGS Trial: Vertical Section—Well B

- Fluid density: 865 kg/m\(^3\) w/ ~9% V/V HGS
- Annular velocity: 50 m/min
- Pump rate of 3.2 m\(^3\)/min
- ECD of 890 kg/m\(^3\)

**Losses were reduced by ~445 m\(^3\) and rate of penetration (ROP) increased by 36%**
HGS Trial: Vertical Section—Well C

- IEF from Well B was reused on Well C cost reduction
  - Fluid density: 825 kg/m³ w/ ~11% V/V HGS
  - Annular velocity: 47 m/min
  - Pump rate of 3.0 m³/min
  - ECD of 840 kg/m³

Loss rate was same as Well B and ROP increased by 45%
## Well Performance Analysis

<table>
<thead>
<tr>
<th></th>
<th>Total Days</th>
<th>Cost Improvement</th>
<th>Total Losses (m³)</th>
<th>Rate of Losses (m³/100 m)</th>
<th>Avg. ROP (m/hr)</th>
<th>Density (kg/m³)</th>
<th>Yield Point (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>BASE</td>
<td>537</td>
<td>31.8</td>
<td>10.2</td>
<td>1010</td>
<td>2.9</td>
</tr>
<tr>
<td>B*</td>
<td>9</td>
<td>-6%</td>
<td>88</td>
<td>5.51</td>
<td>13.6</td>
<td>865</td>
<td>4.3</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>24%</td>
<td>75</td>
<td>5.47</td>
<td>14.6</td>
<td>825</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*36 hours of NPT associated with two extra bit trips. Taking this NPT out of the analysis would have casing point reached in 6.5 days and a 20% improvement to overall costs.

Note: Wells B & C used a low toxicity linear alpha olefin base oil in IEF.
Well Performance Analysis

Intermediate ROP

Depth Vs. Cost

~ 24% improvement
Conclusions

- Density reduced
- Losses minimized
- NPT decreased
- ROP increased—added benefit
- Cost reduced—fluid reused
- Safer and more economical than conventional underbalanced drilling with nitrogen

The addition of HGS is a cost-effective solution to help reduce fluid loss in the Kakwa field of the Western Canadian Sedimentary basin
Acknowledgements

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Thank You

Discussion?