Gas Lift Diagnostic Using Distributed Temperature and CO2 Tracer Survey

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Outline

• Artificial Method

• Gas Lift Overview

• What is Distributed Temperature Sensor (DTS)
  – Principle of Distributed Temperature Sensor (DTS)
  – Field Application of DTS on Gas Lift Surveillance

• What is the CO-2 Tracer survey
  – Principle of Distributed Temperature Sensor (DTS)
  – Field Application of DTS on Gas Lift Surveillance

• Conclusion
Oil Industry Evolution

Where do we go from here?
• Cut backs on drilling and exploration
• Fewer Rigs
• Cost Cutting Measures
• Focus on Production Optimization
  • Asset maturation

West Texas Intermediate (WTI or NYMEX) crude oil prices

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# Artificial Lift Methods

<table>
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<tr>
<th>Method</th>
<th>Diagram</th>
<th>Reservoir Pressure Drops over time</th>
<th>Flow Rate (BBL/D)</th>
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<td>Plunger Lift</td>
<td><img src="plunger_lift.png" alt="Diagram" /></td>
<td><img src="plunger_lift_pressure.png" alt="Pressure Drop" /></td>
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<td>Foam Lift</td>
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<td>Hydraulic Lift</td>
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<td>ESP</td>
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<td><img src="esp_flow.png" alt="Flow Rate" /></td>
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<tr>
<td>Gas-Lift</td>
<td><img src="gas_lift.png" alt="Diagram" /></td>
<td><img src="gas_lift_pressure.png" alt="Pressure Drop" /></td>
<td><img src="gas_lift_flow.png" alt="Flow Rate" /></td>
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</table>

- **Low**: 200 - 500
- **Medium**: 5000 - 6000
- **High**: 35000 - 75000
Gas Lift Operational Consideration

<table>
<thead>
<tr>
<th></th>
<th>Typical Range</th>
<th>Maximum*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Depth (TVD)</td>
<td>5000’ – 10,000’</td>
<td>15,000’</td>
</tr>
<tr>
<td>Volume</td>
<td>100 - 10,000 BPD</td>
<td>30,000 BPD</td>
</tr>
<tr>
<td>Temperature</td>
<td>100 to 250° F</td>
<td>400° F</td>
</tr>
<tr>
<td>Well Deviation</td>
<td>0 to 50°</td>
<td>70° Short to Medium Radius</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Good to Excellent (with Upgraded Materials)</td>
<td></td>
</tr>
<tr>
<td>Gas Handling</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Solids Handling</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Fluid Gravity</td>
<td>Best in &gt;15° API</td>
<td></td>
</tr>
<tr>
<td>Servicing</td>
<td>Wireline or Workover Rig</td>
<td></td>
</tr>
<tr>
<td>Prime Mover</td>
<td>Compressor</td>
<td></td>
</tr>
<tr>
<td>Offshore</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>10% – 30%</td>
<td></td>
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</tbody>
</table>

*Requires special analysis
Gas Lift Overview

• An artificial lift method that
  – Supplements formation gas to lift well fluids
  – Handles a wide range of producing conditions
  – Hides inefficiencies making it hard to maximize production while saving injection gas

• Maintaining gas-lift efficiency requires surveillance
  – Lift as deeply as possible
  – Operate wells under stable conditions
  – Optimize lift gas while maximizing production
Gas Lift Challenges

- Unable to identify which gas lift valve is injecting
- Complicated dual string wells whereby gas lift gas split factor is hard to determined
- Unstable and slugging production from well
- Unable to run gas lift optimization on a field level

* Gas lift surveillances require to validate all the challenges and efficiencies
Optimization and Surveillance

- **Pressure gradient and temperature survey**
  - DTS technology acquire the distributed temperature profile, enabling the operator to monitor simultaneously all the temperature events into the well

- **Tracer survey**
  - CO-2 injection to determine gas lift injection point depth
What is DTS

The fiber is the sensor

Measurements all along a 10km fiber = 10,000 sensors!!

Backscattered light provides measurement point every 1m
DTS Operating Principle

• A pulse of light is sent down to the fiber
• Backscattered from molecules in the fiber is measured at the detector
• Anti stokes Raman Bands portion of the backscattered spectrum is directly proportional to the temperature
## Slick line DTS Logging System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature analysis type</td>
<td>Raman scattering</td>
</tr>
<tr>
<td>Accuracy, degC [degF]</td>
<td>&gt; 0.1 [0.18]</td>
</tr>
<tr>
<td>Resolution, degC [degF]</td>
<td>~ 0.1 [0.18]</td>
</tr>
<tr>
<td>Spatial resolution, m [ft]</td>
<td>1 [3.28]</td>
</tr>
<tr>
<td>OD, mm [in]</td>
<td>3.18 [0.125]</td>
</tr>
<tr>
<td>Working pressure rating, MPa [psi]</td>
<td>103 [15,000]</td>
</tr>
<tr>
<td>Max. temperature rating, degC [degF]</td>
<td>125 [257]</td>
</tr>
<tr>
<td>Max. depth, m [ft]</td>
<td>6,096 [20,000]</td>
</tr>
<tr>
<td>Anticorrosive material</td>
<td>Incoloy® alloy for inner and outer tubing; carbon weave jacket, H2S-corrosion resistant, 15%HCL</td>
</tr>
</tbody>
</table>
Consider the following theoretical logging program

6000 ft logging interval
30 ft/min log down pass

- Logging this interval would take ~3.5hrs per pass
- All flowing and injecting wells are dynamic
- Leaking wells, especially annular flow can be extremely dynamic due to annular condition uncertainty
- Temperature tool needs to be at the depth the temperature changes at the same time the temperature change occurs or temperature change needs to be large enough to leave footprint
- Many changes can occur when tool is not in a position to sense these changes
Technical and Operational differentiation: Conventional vs DTS

- Leaking wells, especially annular can be extremely dynamic due to annular condition uncertainty

- Conventional temperature tool needs to be at the depth the temperature changes at the same time the temperature change occurs

- Many changes can occur when tool is not in a position to sense these changes

- DTS will capture the temperature responses throughout the wellbore simultaneously

- Static source of logging in dynamic flow conditions
Case Studies-1
Stationery Pressure and Temperature Survey

• The PLT survey Result
  • PLT survey stop above and below the GL valve for 5-10 minute
  • DTS run with the PLT

• The pressure survey lead the fluid level / injection point at 7,521 ft
Case Studies-1
DTS Flowing Temperature Profile

GLV @ 8,513 ft. is operating

GLV @ 7,521 ft. is operating
CO-2 Well Tracer

• **What is CO-2 Tracer**
  – Another type of gas lift surveillance
  – Patented technology that traces the path of injected CO2 in a producing well originally developed by Shell
  – Noninvasive method to determine downhole condition leaving well flow undisturbed

• **How does Well Tracer work?**
  – Man-portable
  – Requires temporary connection point on the gas injection line and production line
  – CO2 is injected in the annulus and sensed when it return on the production line

  CO2 tracer Method
Technology Overview

CO-2 Tracer offers a low cost and effective method to determine lift gas entry points in the well quickly and reliably.

- Detects operating lift depth
- Detects multiple points of injection
- Detects tubing leaks
- Determines lift gas rate through each injection point
- Determines allocation of lift gas to each string of a dual completion well
Case Studies-1

- Continuous gas-lift surveillance and optimisation efforts to realise oil production

2010 Redesign: Well Multi-pointing, due to high oil rate & stability, decided not to replace GL valves. Csg pressure 200 psi over design, GLG inj rate 43% higher than design.

2011 WellTracer® Results: CO2 returns show 2nd gas lift valve leaking & lifting from 5th GL valve. Appears bottom valve failed closed & never opened to remove fluid from the casing at depth. Csg pressure & GLG inj rate @ design.

2012 WellTracer® Results: Multi-pointing through 3rd, 5th & 6th valves. Significant uplift possible if able to lift from bottom mandrel only. Estimated PI ~2.824. Run FPT, compare results with 2011 & 2012 WT Surveys (Completed). Redesign, current inj rate @ 5.024 MCFPD. Reduce GLG inj rate.


GLV 3746'
GLV 4493'
GLV 5074'
GLV 5697'

GLV 6279'
GLV 6902'

Reducing multi-pointing and deepening injection depth

37th Gas-Lift Workshop
Houston, Texas, USA
February 3 – 7, 2014

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Reduction multi-pointing and deepening injection depth

2014 Gas-Lift Workshop

Feb. 3 – 7, 2014

2014 Gas-Lift Workshop
Case Studies-2

WinGLUE analysis indicates the POI is through the RDO-20 Orifice Valve at the 4th mandrel depth (1539m).

Well Tracer analysis indicates the installation is multi-pointing through a leaking R20 GLV at the 3rd mandrel depth (1284m), the orifice valve at the 4th mandrel depth and several ill-defined leaks in the vicinity of the 5th mandrel depth (1784m), with no other apparent leaks above the 3rd mandrel depth.

SCADA instrumentation for THP & CHP is in calibration while the instrumentation for LGR was not recorded with the SCADA data during the well tracer survey.

Following remedial action to repair leaks and a redesign of the GLV installation moving the orifice valve down the hole to as deeply as the 7th mandrel depth (2283m) should result in a significant uplift in oil production (See the Equilibrium Rates – Installed data on Sheet 1).

Remarks

Confirms the tubing/mandrel leaks in the vicinity of the 5th mandrel depth and repair as necessary.

Recommendations

A redesign of the installation and GLVCO are recommended moving the RDO-20 Orifice Valve down to as deep at the 7th mandrel depth (2283m). This should result in an oil production uplift in excess of 10 M3/day.

Check the instrumentation for LGR for operability and recalibrate if necessary.
Conclusion

- Gas lift surveillances are key important to optimize the well performance
  - Distributed Temperature Survey
    - With a conventional pressure / temperature survey is possible to identify the operating GLV if the well is flowing only in a stable condition.
    - DTS surveys can identify the operating valves if the well is operating in either a stable or unstable condition.
  - CO-2 Injection Tracer Survey
    - Able to identify which valves are opening and injecting
    - Detects multiple points of injection
    - Detects tubing leaks
    - Require no shut-in
    - No down hole tool
Thank you