Field Testing of an Automated Well Tester in a Heavy Oil Application

Rafael Bastardo, Weatherford
José Scoglio, Petrozuata
Asher Imam, Weatherford
Outline

• Project Profile
  – The MPM (Multiphase Flow Metering) evaluation program
  – Description of test unit

• Process and Instrumentation
  – Gas-liquid cylindrical cyclone technology
  – Metering challenges

• Test Results
  – Impact of diluent

• Discussions
  – Water-cut results
  – Liquid volume results

• Conclusion
Field Operations

• **Current Well Testing Equipment:**
  - Could not measure water cut in real-time.
  - High maintenance issues (moving parts with heavy crude)

• **Objective:**
  - Test a partial separation MPM to see if it could meter the wells productions
  - **Accuracy:**
    • ± 10% Accuracy of total liquid volume
    • ± 5% Accuracy of water cut
    • ± 2% Repeatability
### Partial Separation System (PSS)

Test unit was not designed specifically for Petrozuata test.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Flow Rate</td>
<td>BPD</td>
<td>314</td>
<td>3,774</td>
</tr>
<tr>
<td>Gas Flow Rate (Leg A)</td>
<td>MSCFD</td>
<td>100</td>
<td>1,060</td>
</tr>
<tr>
<td>Gas Flow Rate (Leg B)</td>
<td>MSCFD</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Average Water Cut</td>
<td>%</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Operating Pressure</td>
<td>PSIG</td>
<td>29</td>
<td>200</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>DEG F</td>
<td>100</td>
<td>250</td>
</tr>
<tr>
<td>Viscosity</td>
<td>Cp</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Gas-Liquid Cylindrical Cyclone Technology

- Separates gas from liquid
- Proprietary control algorithm
- Conventional gas and liquid metering equipment
Metering Challenges

• The separator cannot get all of the gas out of the highly viscous liquid.

• Key to success: Ability to meter the viscous oil/water with entrained gas.
  – The Coriolis meter can measure the liquid mass rate accurately with some entrained gas.
  – Red Eye 2G water-cut meter can measure the water cut accurately with some entrained gas.
Calculation of Liquid Volumes

1. \[ \text{mass\_rate}_{\text{liq\_leg}} = \text{mass\_rate}_{\text{liquid}} + \text{mass\_rate}_{\text{entrained\_gas}} \approx 0 \]

2. \[ \text{Net\_Oil\_vol} = (1 - \text{water\_cut}) \times \frac{\text{mass\_rate}_{\text{Liq\_leg}}}{\rho_{\text{calculated}}} \]

3. \[ \text{Net\_Water\_vol} = (\text{water\_cut}) \times \frac{\text{mass\_rate}_{\text{Liq\_leg}}}{\rho_{\text{calculated}}} \]

4. \[ \rho_{\text{calculated}} = \text{water\_cut} \times \rho_{H2O} + (1 - \text{water\_cut}) \times \rho_{Oil} \]
Liquid Measurement

• **References used:**
  - Frac tank used for total liquid volumes
  - Hand samples for water cut measurements

• **Liquid Metering Challenges:**
  - Impact of diluent on crude properties.
  - Error due to assuming fixed oil density.
Test Results - Impact of Diluent

- Normal Field Operating Conditions
  - 15 to 25% diluent injection
Test Results - Impact of Diluent

- **Small Percentages of Diluent**
  - Below the minimum 15%
  - Total liquid volume overestimation
Test Results - Impact of Diluent

- **Large Percentages of Diluent**
  - Above the maximum 25%
  - Large amounts of diluent decreases oil density significantly
  - Total liquid volume underestimation due to fixed oil density
Water-Cut Results

- **Well Pad A**
  - *Red Eye* 2G meter calibrated with well specific calibrations

- **Well Pad B & C**
  - *Red Eye* 2G meter calibrated with global calibrations

![Graph showing water-cut results for Well Pad A and Well Pad B & C](chart.png)

- **Calibrated Red Eye**
  - Well Pad A

- **Generic Calibrations**
  - Well Pad B & C

- **Details**
  - No. Wells: 16
  - API: 11-19
  - Temperature: 98-110 F
  - Pressure: 100-170 psig

![Graph showing water-cut difference](chart.png)
Liquid Volume Results

No. Wells: 16
API: 11-19
Temperature: 98-110 F
Pressure: 100-170 psig
Conclusion

- Partial Separation system is an option for measuring heavy crude production.
- The amount of Injected Diluent had a Large Impact on properties of the Petrozuata oil and the equipment performance.
- Weatherford PSS Qualified as Successful:
  - Total liquid volume accuracy of ±10% with confidence factor of 90% and ±2% repeatability
  - With well specific calibrations, Red Eye 2G water cut accuracy was within ±5%
Keys to Success

• **Successful Collaboration of PSS Components**
  
  – GLCC technology – able to separate flow sufficiently to effectively meter.
  
  – Level control logic – key to operating partial separation system.
  
  – Coriolis-*Red Eye* 2G meter combination – accurately measure flow rates and water-cut with some entrained gas.
  
  – The open architecture, flow metering technology, flexibility, easy operation /diagnostics show PSS units is an excellent solution for heavy oil applications.