I’ve Fixed the Liquid Loading Problem, What Happened to the Condensate?

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Overview

- Use compression to deliquify wells
  - Reduce surface operating pressure
  - Increase well’s flow velocity > critical velocity
  - Improve efficiency in liquids removal
- Focus on condensate production
  - Enhanced economics with current prices
- Optimized well
  - Stabilized gas rate
  - Possible reduction in condensate rate
Calculated CGR
Separator Optimization

- Peng-Robinson Equation of State (EOS) used for optimization calculations
- Condensate is a light, volatile liquid
- Producing condensate-gas ratio (CGR) is a function of separator conditions
- Literature examples for oil wells
- Examine a range of gas-condensates (lean-to-rich) to investigate performance tendencies
2 Stage Separation Facilities

Reservoir → Well → Separator → Gas → VRU → Stock Tank → Oil Sales

Well

Separator

Gas

Oil

Stock Tank

Oil Sales
Oil Well Optimization Example

Example Oil Case

Optimized at maximum API, minimum GOR & FVF
Effect of Temperature

Example Oil Case

API Gravity vs. 1st Stage Pressure, psig

Example Oil Case

Total GOR, SCF/STB vs. 1st Stage Pressure, psig
## Product Prices

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>55.00 $/STB</td>
</tr>
<tr>
<td>Gas</td>
<td>3.00 $/MMBtu</td>
</tr>
<tr>
<td>Ethane</td>
<td>0.25 $/Gal</td>
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<tr>
<td>Propane</td>
<td>0.95 $/Gal</td>
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<tr>
<td>Butanes</td>
<td>1.05 $/Gal</td>
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<tr>
<td>Pentanes-plus</td>
<td>1.20 $/Gal</td>
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<tr>
<td>Component</td>
<td>Efficiency</td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
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<tr>
<td>C2</td>
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<tr>
<td>C6+</td>
<td>0.98</td>
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</table>
Revenue Distribution – Oil Well

Example Oil Case - Revenue Distribution

Fraction of Total Revenue

1st Stage Pressure, psig

- Oil
- Gas
- Plant Liquids
CGR Optimization
2 Stage, CGR = 20 STB/MMCF
CGR Change at Low Pressure
2 Stage, CGR= 20 STB/MMCF

Fraction of Maximum Yield - 2 Stage, 1st Stage 35 psig, 75 °F

Condensate-Gas Ratio, STB/MMCF

Fraction of Maximum CGR

Condensates
Black Oils
Change in Gas Properties
2 Stage, CGR= 20 STB/MMCF
Revenue Distribution
2 Stage, CGR= 20 STB/MMCF
Natural Gas Heating Value

![Natural Gas Heating Value Graph]

- **Y-axis:** Dry Heating Value, MMBtu/MSCF
- **X-axis:** Hydrocarbon Gas Gravity

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*2018 Artificial Lift Strategies for Unconventional Wells Workshop*

*Oklahoma City, OK*
Gas Gravity & Plant Liquid Yield

Plant Liquid Yield

High Efficiency Plant Associated Gases
Revenue Optimization

2 Stage, CGR= 20 STB/MMCF
Revenue Optimization
2 Stage, Different CGR & GOR

Change in Revenue

% Change

1st Stage Separator Pressure, psig

CGR=5 STB/MMCF
CGR=20 STB/MMCF
CGR=50 STB/MMCF
CGR=100 STB/MMCF
CGR=150 STB/MMCF
GOR=600 SCF/STB
Historical Oil & Gas Price

Natural Gas & WTI Oil Historical Prices

Henry Hub Gas Price, $/MMBtu

WTI Spot Oil Price, $/STB
3 Stage Separation Facilities

Note: 2\textsuperscript{nd} Stage fixed at 20 psia & 125 °F
CGR Change at Low Pressure
3 Stage, CGR= 20 STB/MMCF

Fraction of Maximum Yield - 3 Stage, 1st Stage 35 psig, 75 °F

Condensates
Black Oils

Condensate-Gas Ratio, STB/MMCF
Change in Gas Properties
3 Stage, CGR= 20 STB/MMCF
Variation in Revenue Streams

Change in Revenue

<table>
<thead>
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<th>% Change</th>
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<tr>
<td>-1.00</td>
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<tr>
<td>-0.75</td>
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<td>-0.50</td>
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<tr>
<td>-0.25</td>
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<td>0.00</td>
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</table>

<table>
<thead>
<tr>
<th>1st Stage Pressure, psig</th>
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</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
<td>250</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>750</td>
</tr>
<tr>
<td>1,000</td>
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</table>

- 2 Stage
- 3 Stage

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Observations

- Surface operating pressure
  - Reduction necessary to maintain production
  - Effect on rate does not correspond to a similar effect on value

- Oil Well Optimization (traditional recommendation)
  - Maximize Oil API
  - Minimize GOR
  - Minimize Oil FVF

- Oils - revenue is dominated by oil value

- Gas-condensate Well Optimization
  - Lean CGR systems - revenue dominated by gas and plant liquid value
  - Significant decline in yield can occur at low separator pressure
  - Revenue change small compared with CGR change
Other Considerations

- Revenue optimization
  - Ensures value is maximized for all well performance and product price scenarios
- Gas condensate well revenue dominated by gas stream sourced sales
  - Plant liquids
  - Gas Btu
  - Ensure timely gas compositional analyses to secure value
Pipeline Transport of Rich Gases
2 Stage, Tsep=75 °F, CGR= 20 STB/MMCF
Pipeline Transport of Rich Gases
2 Stage, Tsep=75 °F, CGR= 20 STB/MMCF
Final Observations

- Rich gas pipeline transport
  - Low separator pressure results in richer gas
  - Susceptible to liquids dropout in line
    - Higher dropout at lower temperature
  - Dropout of heavy gas components
    - Gas shrinkage
    - Reduction in gas gravity
      - Reduced plant liquid yield
      - Reduced plant liquid value

- Know your operation
  - Avoid pitfalls that effect operational and revenue streams
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