Single Point/High Pressure Gas Lift -
A Simple Efficient Option for the Life of the Well?

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High Pressure Gas-Lift: Is Industry Missing a Potentially Huge Application to Horizontal Wells?
History of Conventional Gas-Lift CGL

Traditional onshore gas-lift designed for ~ 1000 psi

- 25000 patents between 1929 and 1945
  - Culminating in the W.R. King bellows design
  - Minimal innovation since then

- Historical method for large unitized oil fields
  - Large centralized compressor stations
  - Gas plant removed rich hydrocarbons, water vapor, impurities
  - Gas reinjection and waterfloods for pressure maintenance
  - Lean, dry, impurity free gas utilized for gas-lift
History of CGL

Translated well to Offshore

Does not translate well to unconventionals

- Individual leases/highly leveraged companies in competitive situations drive goal for low flowing BHP
- No pressure maintenance
- Raw wellhead gas is re-injected downhole
- Methanol injected to prevent hydrate issues
What is Single Point/High Pressure Gas-Lift?

- Single Point Gas-Lift (SPGL) – Gas Injection for artificial lift at one location only, no gas lift valves, generally around the end of the tubing

- High Pressure Gas-Lift (HPGL) – SPGL where there is injection pressure available to lift a column of completion or frac fluid (if installed early in the life) or produced fluid (if installed after well has cleaned up and is producing reservoir fluid only)
What is SP/HPGL?

• With no GL valves SPGL Can handle reservoir pressures up to 7000 psi at 10,000 feet when gas column gradient considered

• Enabled by
  • Advent of CNG compression equipment (up to 6000 psig)
  • High pressure wellheads and casings for fracturing purposes
  • Horsepower proportional to compression ratio, not pressure
What is SP/HPGL Gas-Lift?

- Injection pressure simply the producing BHP when gas head and friction corrected.
- Similar to unloading a well with coiled tubing and nitrogen (jetting a well).
What is SP/HPGL Gas-Lift?

IT IS NOT NEW:

- High Pressure Gas-Lift (HPGL) per Dickens in SPE 14347
  - “A deep gas-injection depth minimizes the gas volume required to reach the minimum flowing gradient, providing the maximum drawdown at the perforation depth.”

- Used 3000 psi injection pressure with 5 mandrels at depths of 15,200 feet for substantial production increases
What is SP/HPGL Gas-Lift?

IT IS NOT NEW:

• Continuous Gas Circulation (CGC) by Hacksma SPE 37426
  • A version of SPGL where gas is injected around the end of the tubing at a rate that results in tubing velocities above critical rate
  • Applicable at conventional or high pressures, and can be a permanent lift method
What is SP/HPGL Gas-Lift?

IT IS NOT NEW:

- Single Point Gas-Lift (SPGL) per Kumar in SPE 80531
  - “It is an age-old concept, and is nothing but a simple means of injecting gas through one point in the string down below a liquid column to lift from the desired depth.”

- Applications in several North Sea fields, offshore Dubai, and onshore Hungary
Benefits of SP/HPGL

- Potential to lower FBHP and Increase Production

- [http://petrowiki.org/Gas_lift](http://petrowiki.org/Gas_lift) On Conventional GL - “Relatively high backpressure may seriously restrict production in continuous gas lift. This problem becomes more significant with increasing depths and declining static BHPs. Thus, a 10,000-ft well with a static BHP of 1,000 psi and a PI of 1.0 bpd/psi would be difficult to lift with the standard continuous-flow gas-lift system. However, there are special schemes available for such wells.” (chambers)
Benefits of SP/HPGL

- Presence of gas throughout the entire flow string, not just from the gas-lift valve to surface
  - Increases efficiency and effectiveness of injected gas
  - Allows corrosion inhibitor to treat entire tubing string/casing annulus
  - Eliminates gas-lift valves, and the staff and tools for designing/diagnosing/fixing gas-lift valve issues
  - No packers, Surface pressure provides real-time estimate of BHP

- As well depletes and BHP drops, injection pressure declines to that of conventional gas-lift and below (HPGL to SPGL) with no Side Pocket Mandrels or Valves to deal with
Do you believe gas will "turn the corner" (worst case)
Do you believe gas will “turn the corner”

- Why does gas displace liquid almost perfectly?
- No different than displacement to first gas lift valve
Do you believe gas will “turn the corner”

- Pressures are essentially equal at end of tubing, in tubing, in annulus and in perfs

- Reservoir pressure = \( P_{\text{casing}} + \text{Gas Column} = P_{\text{tubing}} + \text{liquid column} \)
Do you believe gas will “turn the corner”?

- Will gravity separation work once liquid in annulus displaced just below end of tubing?
- Bubbles of liquid start rising, lightening column and starting flow
- Liquid drops and liquid and gas exchange places
Do you believe gas will “turn the corner”

• In the experience of J. Hacksma and the authors, misunderstanding of this concept is a major reason why SPGL has not been used.

• Again perspective difference between those experienced with open annulus gas wells vs. liquid wells with packers.
For early life rates above 1000 BFPD, operators sometimes choose ESP’s

- ESP’s may have short operating life due to sand and deviation
- Replacement costs and downtime costs are high
- Use external energy source to offset friction losses up tubing
- Use centrifugal gas separator to handle gas

Conventional or SPGL Gas-Lift limited by tubing friction
Annular Gas-Lift can compete rate-wise with ESP’s in the early life of well

Reverse Flow solves the problem of friction loss associated with high tubing flowrates

Cross-sectional area up to 3 times greater than tubing

HPGL can put large volumes through small tubing
  • Compressor provides energy for overcoming friction down tubing
High Productivity Case with Varying Flow Paths

- **Well and Analysis Parameters**
  - 5-1/2” P-110 Casing; Formation TVD 10998; Formation Temp 280F
  - Effective Reservoir Pressure 4000 psia; 10% Water; Oil Gravity 45 API – 125 psig Surface Pressure
  - High Productivity Case

### Table 2. High Productivity Cases with Varying Flow Paths

<table>
<thead>
<tr>
<th>Flow Path</th>
<th>Max. BLPD</th>
<th>Lift Gas, MCFD</th>
<th>BHP, psia</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 3/8&quot; Tubing</td>
<td>1410</td>
<td>600</td>
<td>2850</td>
</tr>
<tr>
<td>2 7/8&quot; Tubing</td>
<td>1900</td>
<td>600</td>
<td>2450</td>
</tr>
<tr>
<td>5.5&quot;x2 7/8&quot; Ann.</td>
<td>2860</td>
<td>1200</td>
<td>1620</td>
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<tr>
<td>5.5&quot;x2 3/8&quot; Ann.</td>
<td>3000</td>
<td>1200</td>
<td>1470</td>
</tr>
</tbody>
</table>
Low Productivity Case with Tubing Flow Only

- Well and Analysis Parameters
  - Low Productivity Case, all other items same

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<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>2 3/8&quot; Tubing</td>
<td>49</td>
<td>200</td>
<td>290</td>
</tr>
<tr>
<td>2 7/8&quot; Tubing</td>
<td>50</td>
<td>300</td>
<td>260</td>
</tr>
</tbody>
</table>

- SPGL efficiently produces from 3000 BLPD at 1470 psia BHP to 49 BLPD at 290 psia with no changes in tubulars or equipment

- Allows SPGL to be the single and only form of artificial lift needed

"Life Cycle" of Artificial Lift? – save your $$

Feb. 4 - 7, 2018

2018 Artificial Lift Strategies for Unconventional Wells Workshop
Oklahoma City, OK
Special Thanks to Branden Pronk with SM Energy for the Following Slides on Actual Performance of ESP vs. Estimated HPGL on a Wolfcamp Well
IPR CURVES VS. TBG PERFORMANCE CURVES

Pressure (psi) vs. Production (bbl/day)

ESP

Day 4

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IPR CURVES VS. TBG PERFORMANCE CURVES

High Pressure Gas Lift (Annular Flow)
1.5 MMCFD Injection

Day 4
ESP
Day 10

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**IPR CURVES VS. TBG PERFORMANCE CURVES**

High Pressure Gas Lift (Annular Flow)  
1.5 MMCFD Injection

**Pressure (psi)**

**Production (bbl/day)**

- **ESP**
- Day 90
- Day 60
- Day 30
- Day 4
- Day 10

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High Pressure Gas Lift (Annular Flow)
1.5 MMCFD Injection

IPR CURVES VS. TBG PERFORMANCE CURVES

Day 4
Day 10
Day 30
Day 60
Day 90
Day 120

ESP
Day 120
Conventional Gas Lift (Tubing Flow)
1.5 MMCFD Injection

High Pressure Gas Lift (Annular Flow)
1.5 MMCFD Injection

Day 4

Day 120
Packer/ Orifice, or Open-Ended Tubing?

- Well “stability” cannot be provided by packer and orifice
  - Slugs from lateral

- Reality of not installing a packer, mandrel, and orifice
  - Reduces installation costs
  - Reduces likelihood of future fishing jobs
  - *Old PE Adage* – “Never run anything below the master valve that is not absolutely necessary”

- Handling slugs/ instability is solvable facility problem

- Which is better for the well: Stability or Optimization?
Compression Choice for HPGL

• Compress low pressure gas at wellsite using multiple stages

• Distribute gas at ~400 to 1000 psi from central, boost using one or two stage wellsite compressor

• In Either Case Wellhead Compressor Used at Least Early Life
  • 5000 psi injection lines?
Wellhead Booster Compressor in HPGL Service

- 1000 to 4000 psig @ 1.25 MMCFD
- 100 hp
- Two stage electric
- ~ 15’x7’ Skid

- Based on good performance of these units - 5 More units are now being commissioned and 10 more are being built (similar to this one with Natural Gas Engine Drivers)
Summary – HPGL/SPGL

- Is a viable alternate to ESP’s and potentially other AL methods
- With ASPGL may work efficiently for life of well
- Reduces in-well equipment/intervention
- Requires teamwork between PE/RE/FE/compressor provider
- Shifts the service company revenue from well companies to facility companies
Summary – HPGL/SPGL

• Needs more technical/industry focus

• Join us at https://highpressuregaslift.info/
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