High Pressure Gas-Lift: Is Industry Missing a Potentially Huge Application to Horizontal Oil Wells?

- Bill Elmer, P.E.
- Encline Artificial Lift Technologies LLC
What is High Pressure Gas-Lift

• Operating at Elevated Surface Pressures
  – Surface injection pressures up to ~4000 psi
    • CNG compressor cylinders, 5000# casing ratings
  – Injection pressure simply the producing BHP when gas head and friction calculated
  – Similar to unloading well with coiled tubing and nitrogen
  – Practiced to a degree offshore
What is High Pressure Gas-Lift

• Possible elimination of Gas-Lift Valves
  – If producing BHP below 4500 psi, can inject through orifice above packer
    • Otherwise known as single point injection
    • No gas-lift valve required
  – One valve increases this to ~6000 psi
What is High Pressure Gas-Lift

• Presence of gas throughout entire flow string, not just from the gas-lift valve to surface
  – Increases the efficiency and effectiveness of injected gas

• As well declines, injection pressure declines to that of conventional gas-lift
  – High Pressure only present when needed due to higher BHP
  – Limited downside
What is the Application for Horizontal Oil Wells?

- Makes annular gas-lift possible using small tubing
- Can potentially eliminate expensive and failure prone ESP’s as initial form of artificial lift
- Allows Gas-Lift to be the single and only form of artificial lift needed
  - “Life Cycle” of Artificial Lift?
Gas-Lift Training Video (Youtube – Diker)
Traditional gaslift utilizes designs that begin in the 1000 psi injection pressure range:

- As flowing BHP falls, injection drops to lower valves, and ultimately an orifice just above the packer.
- Injection pressures steadily decrease while working way down to orifice.
- FBHP’s around 500 psig possible for 10000 Foot depth for liquid rates below 50 BPD.
Traditional Gaslift / Continuous Gas Circulation

- As fluid volumes fall, GOR increases to the point that the well essentially behaves as a gas well
  - Concept of CGC (Continuous Gas Circulation – Jim Hacksma at 2008 Gas Well Deliquification Workshop) comes into play
  - Efficiency can be improved by adding plunger (Eric Perner / Stan Lusk at 2015 Gas Well Deliquification Workshop) and handle rates of 200-250 BFPD
  - FBHP’s around 300 psig possible for 10000 Foot depth

- Gas-Lift can be a cradle to grave operation
Limitations of Traditional Gaslift

- Normal tubing diameters pose a restriction at rates above 500 BFPD, as gas occupies a large percentage volume inside the tubing
  - Hence, only large tubing or reverse flow can lift high volumes
  - Many operators utilize submersible lift for new horizontal wells, where external energy is used to offset the friction of flowing up these small tubing diameters
Limitations of Traditional Gaslift

• Alternative of Reverse Flow solves problem of friction loss, as cross-sectional area is up to 3 times greater
  – 5-1/2” 23# casing with 2-1/16” IJ tubing has annular capacity of .0957 ft³/ foot
  – 2-7/8” 6.5#, the largest size for 5-1/2” casing, has capacity of .0325 ft³/ foot
  – Annular area is 2.95 times the tubing area
  – High Pressure Gas-Lift enables large volumes to be transported to the bottom of the well through a small conduit such as 2-1/16” IJ tubing
High Pressure Gas-Lift History

• Apparently has been used offshore with large tubing diameters
  – Conventional flow direction used due to safety valves
  – Schlumberger Xlift Valve developed for High Pressure
    • Originally designed for deepwater gas-lift
    • Provide deeper injection points, 5000 psi injection

• Literature scan showed injection pressures of 1600 to 1850 psig, but hearsay says up to 5000 psi common offshore

• This is nothing new…
High Pressure Gas-Lift History

- SPE 14347 by R.J. Dickens of Exxon in 1988: High-Pressure Gas Lift for Deep, Sour Production
  - High Pressure Gas-Lift used to produce sour Smackover formation at 15,200 feet in Jay Field in Florida by Exxon
  - Although 7000 psi available, 3000 psi injection pressure with “two or three” mandrels chosen due to casing integrity concerns

“A deep gas-injection depth minimizes the injection gas volume required to reach the minimum flowing gradient, providing for the maximum drawdown at the perforation depth.”
High Pressure Gas-Lift

Why is it applicable now?

- Operators desire to produce new horizontal oil wells at high rates to improve their profitability
  - Traditional gas-lift up tubing underperforms submersible lift in this application
- With annular lift, frictional losses are born by the compressor, and formation does not see them (similar to ESP’s)
- ESP’s have short operating life, and are expensive to replace
High Pressure Gas-Lift

- Example: Cat 3512 4 Stage 1000 HP Compressor
  - Capable of moving 3.6 MMCFPD from 45 to 4000 psi
  - 10,000 feet of 2-1/16” IJ tubing
  - 4000 psi surface injection pressure
    - Frictional loss of 300 psi
    - Gas head adds 1000 psi depending on temperature (Z factor)

\[
P_v = P_s \left( \frac{0.01875 \gamma_g D}{T_{avg} Z_{avg}} \right)
\]

- Potentially 4700 psi BHP

\[
P_v = P_s e
\]
High Pressure Gas-Lift

• Takeaways:
  – Can dead lift fluid if BHP 4700 psi or less
  – For 2000 BPD well, 3.6 MMSCF/DPD is an 1800 GOR boost
  – Coiled tubing looks even better, with continuous exterior OD eliminating turbulence around joints
  – Once well has depleted, can go to traditional gas-lift
Evaluating a Candidate Well

• Suggested Exercise:
  – Prepare family of IPR curves for candidate wells
  – Prepare outflow curve for ESP
  – Prepare outflow curve for High Pressure Gas-Lift
  – Compare difference and costs, especially submersible lift anticipated failure and operating costs

• Results of a single analysis: 80/20 Rule
  – 80% of the production with 20% of the cost
Chicken or the Egg?

• Obviously four stage compressors are not presently available
  – This is because E&P operators are not asking for them
  – If there is a demand for them, compressor industry will eventually get there, but initially operators will have to purchase some until this is a proven practice

• So, be willing to sign a long term contract to get the machine built
  – The compressor will also be able to meet lower pressure gaslift requirements if designed well
Compressor Performance at both 4000 psi and 600 psi discharge

1.46 MM from 45 PS to 4000 PD, using 398 HP

1.519 MM from 45 PS to 600 PD, using 248 HP. Load decrease of only 38%. Improve loading by raising PS
Rights to this presentation are owned by the company(ies) and/or author(s) listed on the title page. By submitting this presentation to the Gas-Lift Workshop, they grant to the Workshop, the Artificial Lift Research and Development Council (ALRDC), and the American Society of Mechanical Engineers (ASME), rights to:

- Display the presentation at the Workshop.
- Place it on the www.alrdc.com web site, with access to the site to be as directed by the Workshop Steering Committee.
- Place it on a CD for distribution and/or sale as directed by the Workshop Steering Committee.

Other uses of this presentation are prohibited without the expressed written permission of the company(ies) and/or author(s) who own it and the Workshop Steering Committee.
The following disclaimer shall be included as the last page of a Technical Presentation or Continuing Education Course. A similar disclaimer is included on the front page of the Gas-Lift Workshop Web Site.

The Artificial Lift Research and Development Council and its officers and trustees, and the Gas-Lift Workshop Steering Committee members, and their supporting organizations and companies (here-in-after referred to as the Sponsoring Organizations), and the author(s) of this Technical Presentation or Continuing Education Training Course and their company(ies), provide this presentation and/or training material at the Gas-Lift Workshop "as is" without any warranty of any kind, express or implied, as to the accuracy of the information or the products or services referred to by any presenter (in so far as such warranties may be excluded under any relevant law) and these members and their companies will not be liable for unlawful actions and any losses or damage that may result from use of any presentation as a consequence of any inaccuracies in, or any omission from, the information which therein may be contained.

The views, opinions, and conclusions expressed in these presentations and/or training materials are those of the author and not necessarily those of the Sponsoring Organizations. The author is solely responsible for the content of the materials.

The Sponsoring Organizations cannot and do not warrant the accuracy of these documents beyond the source documents, although we do make every attempt to work from authoritative sources. The Sponsoring Organizations provide these presentations and/or training materials as a service. The Sponsoring Organizations make no representations or warranties, express or implied, with respect to the presentations and/or training materials, or any part thereof, including any warrantees of title, non-infringement of copyright or patent rights of others, merchantability, or fitness or suitability for any purpose.