Multiphase Compressor to Enhance Artificial Lift Applications

Robert Perry
Hicor Technologies
Game changing artificial lift solution for Unconventional oil & gas reservoirs

- Unconventional reservoirs & wells progression:
  - Drilling Holes
  - Improving Inflow
  - Artificial Lift

- Multiphase compression offers improved:
  - Production
  - Reserves
  - Capital efficiency
  - Emissions benefits

“Increasing the recovery factor of Permian 4% adds the equivalent to the reserves of Saudi Arabia”
How the multiphase compressor works

- A multiphase compressor with high compression ratios:
  - Liquid injection enables compression ratios of up to 40:1
### How the multiphase compressor compares to other technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Multiphase Compressor</th>
<th>Reciprocating Piston / Axial</th>
<th>Rotary Screw Pump Multiphase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Max Boost Ratio per Stage</td>
<td>40:1</td>
<td>4:1</td>
<td>~ 4:1</td>
</tr>
<tr>
<td>Multiphase Capability</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>High Efficiency Dry Gas Capability</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Flexible operating envelope</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>
Artificial lift for unconventional wells

Wellhead Multiphase Compression

Enhancing Artificial Lift

Gas Lift
Plunger Lift
Rod Pump

Feb. 11 - 14, 2019
2019 Artificial Lift Strategies for Unconventional Wells Workshop
Oklahoma City, OK
Artificial lift applications:
Wellhead multiphase compression

- Decreasing Wellhead Flowing Pressure (WHFP) increases superficial gas velocity, reducing tubing holdup (density):
  - Higher superficial velocity sweeps liquids from tubing
Artificial lift applications: Plunger lift

- Decreasing WHFP reduces the back pressure the well produces against.
- Higher differential pressure across the plunger (piston) allows greater weight of fluid to be lifted:

Example:
- Pressure above (less 300 psi)
- Pressure below
- c. 700ft of extra fluid lifted (1500lbs)

Extra drawdown
Artificial lift applications: Gas lift

- Gas lift gas increases superficial gas velocity & reduces tubing density
- Decreasing WHFP:
  - Reduces back pressure gas lifted fluids have to produce against
  - Increases effective tubing GLR
- Allows deeper gas lift making more efficient use of gas lift gas

Tubing size can be optimized for life of field:

<table>
<thead>
<tr>
<th>Early Production (larger)</th>
<th>Later Heading / Slugging (smaller)</th>
</tr>
</thead>
</table>

i.e. select larger tubing for early production, then add HICOR to enhance later life production and avoid tubing heading / slugging
Artificial lift applications: Rod pumps & ESPs

- **Gas interference** (reduced pump efficiency) unable to lower annulus fluid level, **two options:**
  - Reduce casing annulus pressure, larger gas bubbles in the liquid phase at downhole separator, improve separation, reduce gas interference, more effective pumping
  - Act directly on tubing with multiphase wellhead compression without the beam pump
Artificial lift applications (well cleanup):
Wellhead multiphase compression to cleanup ‘frac hit’ gas well

- Existing gas producer well is hit by neighboring infill well frac (‘frac hit’)
- Gas producer is injected with significant quantities of frac fluids
- Gas producer has a new ‘liquid loading’ problem, significantly reducing production
- Use wellhead multiphase compressor to ‘clean up’ gas producer (ie produce frac fluids)
- Once gas producer is cleaned up, it can naturally produce at significantly higher rate without wellhead multiphase compressor
Field validation success: First package

- Deployed across 5 different Eagle Ford wells:
  - Wellhead multiphase compression
  - Plunger

- Focus:
  - Proving value proposition
  - Improving compressor performance
  - Understanding performance envelope

- Package upgraded and redeployed to Permian:
  - Beam pump
Proven value proposition with field data

- **Without Multiphase Gas Compressor (on plunger lift):**
  - Total Gas: 713 MSCF
  - Total Oil: 0 BBL
  - Well uptime - 60% Zero liquids

- **With Multiphase Gas Compressor:**
  - Total Gas: 2388 MSCF
  - Total Oil: 204 BBL
  - Well uptime - 100% Maximum liquids

- **$500k p.a. incremental production** ($1.50/MSCF gas & $40/BBL oil)
- **Payback less than one year**
Field proven: Drawing down wellhead flowing pressure

Natural flow well – actual field data:

With Multiphase Gas Compressor:

Compressor starts to pull well pressure down.

Valuable liquid production is stimulated.

Liquids and gas flow directly through compressor.

High compression ratio flexible enough to pull down well pressure.
Field Proven: Keeping slugging wells unloaded

Natural flow well – actual field data:

- **Multiphase compressor** accommodates multiple small slugs to keep the well unloaded and flowing

- **Flexible operation** as multiphase compressor naturally ‘follows’ required operating conditions

![Graph showing skid inlet pressure, skid discharge pressure, skid gas flowrate, compressor gas flowrate, and discharge liquid flowrate over time. The graph indicates continuous slug unloading.](image)
Field proven: Well unloading to ‘atmosphere’

Natural flow well – actual field data:

- Wet gas compressor unloads well to atmospheric pressure
- Equivalent to open top tank flowback – except all flow goes through compressor
- Significant reduction in environmental emissions

Multiphase compressor demonstrates ability to clear large slugs
Eliminates need for a flowback tank and keeps the hydrocarbons ‘inside the pipe’
Significant reduction in methane emissions through wellhead multiphase compression

Traditional Operations:

Compressor stations typically responsible for 43% of emissions across natural gas supply chain.¹

Operational process upsets and blowdown events

Fugitive emissions from condensate tanks

Liquids unloading

Pneumatic devices vent methane

Separation equipment

Compressor packings

Hicor

Moving into commercialization: Systems & field deployment

1st Commercial Package Being Built:

- Design & long leads complete
- Compressor built
- System being fabricated:

Field Deployment:

- Eagle Ford
- Frac hit gas wells

- Field deployment Mar 2019
Continuing to work with operators

- Seeking field demonstrations for broader track record with wider customer base, with more:
  - Customers
  - Regional basins, and
  - Applications

- Identifying applications within customer’s well portfolios

- Seeking and deploying commercial systems in field to increase production and reserves for operators
Thank you

- Thank you for your attention
- Welcome questions
- Please visit our booth to see our multiphase compressor
Copyright

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 Artificial Lift Strategies for Unconventional Wells Workshop, they grant to the Workshop, the Artificial Lift Research and Development Council (ALRDC), and the Southwestern Petroleum Short Course (SWPSC), 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 use of this presentation is prohibited without the expressed written permission of the author(s). The owner company(ies) and/or author(s) may publish this material in other journals or magazines if they refer to the Artificial Lift Strategies for Unconventional Wells Workshop where it was first presented.
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 Artificial Lift Strategies for Unconventional Wells Web Site.

The Artificial Lift Research and Development Council and its officers and trustees, and the Artificial Lift Strategies for Unconventional Wells 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 Artificial Lift Strategies for Unconventional Wells 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.