Liquid-Assisted Gas-Lift Unloading

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Introduction

• Lower Oil prices spur the industry to find **innovative techniques** to produce more for less money

• Gas-Lift is a well established technique, but it can be improved

• Gas-Lift operations are divided in:
  – Unloading
  – Production

• Two major unloading techniques:
  – **Single-point** gas injection
  – **Multiple-point** gas injection

\[ p_{\text{inj}} = p_{\text{wh}} + \Delta p_{\text{GLV}} + \Delta p_f + (\bar{\rho}_{\text{tb}} - \bar{\rho}_{\text{an}}) gL \]
Introduction

Gas-Lift Unloading – Multiple Valves
Motivation

Multiple Valves

• Introduce potential leak points

Well Integrity

Single-point injection

Introduce potential leak points
Liquid-Assisted Gas-Lift Concept

\[ p_{inj} = p_{wh} + \Delta p_{GLV} + \Delta p_f + (\rho_{tb} - \rho_{an})gL \]

- Starts to Inject Gas + Liquid
- Why?
  - Increase the density of the injection fluid
- The final goal: Inject 100% gas
Problem

**Single-point** gas injection: Requires *high injection pressure*

**Multiple-point** gas injection: Add *potential leak* points and *extra cost*

Objective

*Evaluate the use of Liquid-Assisted Gas-Lift technique as an alternative to unload wells*
Methodology

**Outflow line**
- Injection line
- Outflow line
- Closed Node
- Pressure Node (Return Line)
- Injection Line
- Annulus
- Tubing
- Section 1
- Section 2
- Section 3
- GLV

**Promotional Transient Simulator**
- **Commercial Transient flow simulator**
- **Fluids:** Water and Natural Gas
- **Section 1:** casing/tubing annulus
  - Casing ID: 4.88”
  - Tubing OD: 2.87”
- **Section 2:** production tubing
  - 2.788m vertical
- **Section 3:** gas-lift valve
- Reverse flow check valve
- Orifice Valve: 0.68”
- Compositional fluid model

**LSU Test Well**
- **P and T**
- **q_w**
- **q_g**

**Introduction**

- **Motivation**
- **Problem and Objective**

**LAGL Concept**

**Methodology and Results**

**Conclusions**
### Results

#### Field Scale Well Test

- **$q_w = 50$ gpm**
- **$q_g = 5$ agpm**

\[ P_{\text{inj, max}} \]

- **$q_w = 50$ gpm**
- **$q_g = 10$ agpm**

\[ P_{\text{inj, max}} \]

- **$q_w = 50$ gpm**
- **$q_g = 20$ agpm**

\[ P_{\text{inj, max}} \]

**Gas Injection:**

1,200 psig

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**Simulation**

\[ q_w = 50 \text{ gpm} \]
\[ q_g = 5 \text{ agpm} \]

**Experimental**

\[ q_w = 50 \text{ gpm} \]
\[ q_g = 10 \text{ agpm} \]

\[ q_w = 50 \text{ gpm} \]
\[ q_g = 20 \text{ agpm} \]

**GLR**

**$P_{\text{inj, max}}$**


Results

\[ p_{inj} = p_{wh} + \Delta p_{GLV} + \Delta p_f + (\rho_{tb} - \rho_{an})gL \]

\[ q_g = 20 \text{ gpm} \]

Optimal Injection Interval

Introduction

Motivation

Problem and Objective

LAGL Concept

Methodology and Results

Conclusions
Results

Simulation
- 
- \( q_g = 5 \text{ gpm} \)
- \( q_g = 10 \text{ gpm} \)
- \( q_g = 20 \text{ gpm} \)

Experiment
- 
- \( q_g = 5 \text{ gpm} \)
- \( q_g = 10 \text{ gpm} \)
- \( q_g = 20 \text{ gpm} \)

Optimal injection interval

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<th>( p_{\text{inj, max}} )</th>
<th>Error (%)</th>
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Results
Simulation – Well Unloading

Injection Pressure

Flow Rates (Injection)
- Water
- Gas

Water Volume
- Total (Annulus + Tubing)
- Annulus
- Tubing
Conclusions

• **LAGL** can significantly **reduce injection pressure** required in single-point unloading.

  ![Diagram](image)

  1,200 psig single-phase gas → 300 psig gas-liquid mixture

• The **simulation** results predicted $p_{\text{inj, max}}$ with errors lower than 15% when compared to the experimental data.

• The **simulation model was validated** with experimental data and can be used to optimize the LAGL application.
Acknowledgment:

- Jun Xu
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- Stuart Scott
- Wayne Mabry
- Wesley Williams
Methodology

Two-Phase Flow through Orifice GLV - Flow Loop Test

Injection Pressure Max: 1,500 PSI

Gas and Liquid Injection
Preliminary Results
Two-Phase Flow through Orifice GLV - Flow Loop Test
Results
System Optimization

$q_g = 1.26 \text{ l/sec}$

$q_g (\text{gpm})$

$p_{inj} (\text{psig})$

- 0.69 inch
- 1.00 inch
- 2.00 inch

18% lower
Results

Field Scale Well Test

$q_w = 50 \text{ gpm}$
$q_g = 5 \text{ agpm}$

$q_w = 50 \text{ gpm}$
$q_g = 10 \text{ agpm}$

$q_w = 50 \text{ gpm}$
$q_g = 20 \text{ agpm}$

- Water Volume In (gal)
- Water Volume Out (gal)
- Unloaded Water (gal)

Volume (gal)
Time (sec)

Water Volume In (gal)
Water Volume Out (gal)
Unloaded Water (gal)

320 gal
260 ft

330 gal
570 ft

710 gal
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