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Production Optimisation: A Gas Lift Odyssey

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Senergy

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl
Objectives

- Examine various levels of gas lift “optimisation” in current practice.
- Review recent advances in gas lift technology.
- Identify key challenges for future gas lift operations.
Gas Lift Perspective

Gas Lift as % of Artificial Lift Production

<table>
<thead>
<tr>
<th>Company</th>
<th>Percentage</th>
<th>Year or Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP</td>
<td>46%</td>
<td>2002</td>
</tr>
<tr>
<td>ExxonMobil</td>
<td>53%</td>
<td>2004</td>
</tr>
<tr>
<td>Petrobras</td>
<td>89%</td>
<td>Campos Basin</td>
</tr>
<tr>
<td>Shell</td>
<td>64%</td>
<td>2001</td>
</tr>
<tr>
<td>Qatar Petroleum</td>
<td>35%</td>
<td>2008; of total oil</td>
</tr>
<tr>
<td>PCSB Malaysia</td>
<td>40%</td>
<td>2002; of total oil</td>
</tr>
</tbody>
</table>

source: www.alrdc.com
Stages of Gas Lift Optimisation

1. Design & Implementation
   - tools, equipment, models
2. Single Well Diagnostics & Remediation
   - measurement surveillance
3. Full Field Optimisation - RTO
   - data management, algorithms

problems & evolving solutions exist at each level
The Prize

• Design & Implementation
  – More production can be safely gas lifted
  – Avoidance of costly workovers/re-entries

• Single Well Remediation
  – 0-25% on flowing wells
  – Revival of shut-in wells

• Full Field Optimisation
  – 2-5% oil increase of field wide production
  – Up to 40% improvement in gas injection efficiency
  – Sustained production increases with Real Time Optimisation (RTO)
Stage 1: Evolving Challenges in Gas Lift Design & Implementation

- Gas Lift Rate Control
- Deep Water Completions
- Well Integrity
- Gas Lift Valve Reliability

Source Weatherford
Venturi Orifice Valve

\[ Q_{gi} \text{ (MMSCF/D)} \]

**NORMAL ORIFICE**

\[ P_{TUBING} = 90\% \text{ of } P_{CASING} \]

**VENTURI ORIFICE**

**SUB-CRITICAL FLOW**

\[ P_{TUBING} = 55\% \text{ of } P_{CASING} \]

**CRITICAL FLOW**

**TUBING PRESSURE (psi)**

**P_{CASING}**
Surface Controlled Gas Injection Valve

**Features - adjustability**
- orifice size can change as well conditions change without intervention
- reduces risk of erosion. Can remain “full open” during unloading and then close to necessary orifice size.
- controlling lift gas originating from a gas zone in same well as the oil reservoir (“auto” GL)

**Current Issues**
- Not a new technology
- Specific applications
  - e.g. subsea installations w/o GL control at WH
  - SMART wells
- Expensive for existing developments
- Hydraulic vs. electric control (cable?)
  - Electric cable downhole “…one $2 O-Ring causes US million dollar workovers…”
Advanced Gas Lift Valve Modelling

actual gas rate through IPO as a function of valve performance (inflow) and tubing performance (outflow)
High Pressure Injection Valve

• Features
  – meets “zero intervention” philosophy set for subsea developments
    • High reliability orifice
    • No unloading valves required
    • Fewer leakage paths
  – IPO valves to 5000 psi; Orifice valves to 7500 psi. 10MMscf/d
  – premium materials/elastomers
  – flow path limits erosion
• Current Issues
  – requires a minimum gas injection rate for well stability
  – requires a higher injection pressure (compression)
  – potential valve erosion
  – no flexibility
High Performance Back Check

- Increasing industry emphasis on valve & well integrity
- New valves
  - valve & tubing become first barrier element
  - metal to metal seal at back check
  - spring activated (protected from flow)
  - flow geometry optimised for seal area protection
  - 10,000 psi, 20-180°C, 8.5 MMscf/d
- Qualifies as barrier element under Norsok D10 and StatoilHydro
  - Eliminates need for annular safety valve
  - fewer well interventions/opex
  - deep well performance & integrity
Gas Lift Valve Reliability

• Valve performance
  – Valve Performance Clearing House (joint industry project)

• Valve testing
  – Equipment: Automatic Validation Tester (AVT)
  – QA/QC, valve histories

• Revised API/ISO standards & procedures
Stage 1

• Advances in equipment, software, standards and testing make gas lift designs more robust, repeatable and secure.
Stage 2: Single Well Diagnostics & Remediation

- Maintaining optimum gas injection
  - Valve behaviour
  - Injection depth

- Technology
  - Moving beyond Flowing Gradient Survey + nodal analysis
  - Sensor improvements
  - Dynamic well modelling
  - Multiwell surveillance

- Challenges
  - Increased data load -> overload
  - Increasing lack of gas lift engineering expertise
  - “...gas lift works, even if it’s broken!”
Improving Lift Efficiency
Fibre Optics – Distributed Temperature Sensors/Systems (DTS)

- Simultaneous real time measurements through entire completion
- Permanent installation or slick line
- Temperature vs time vs depth

Source: Schlumberger
CO2 Tracer Injection

- CO2 slug injected into GL supply line
- Produced fluid stream analysed at well head vs. time.
- CO2 peaks correlate with active GL valve or leaks.
- GLV verification & tubing integrity.

Features:
- No shut-in
- No downhole tools
- Alternative to flowing gradient survey (FGS)
- HSE

Source ALRDC/AppSmiths
Dynamic GL Simulation

gas flow through orifice valve

Effect of decreasing Gas injection rate at a constant FTHP

e.g. Dynalift™, OLGA™, FlowLift™
Improved Data Management

- On line data acquisition, storage and analysis
- Conceived for large fields (100’s of wells)
- Surveillance: display, sorting, trending
- Management by exception: alarms/flags
- Offline analysis using engineering applications
- Storage of well service histories
Desktop Intelligence: “Smart” Diagnostics

Artificial Intelligence – a virtual “robot”

- **Monitor** GL well data: CHP/THP, prod/inj rates, GLV data...

- **Expert System knowledge base:** initial “expert” input: define a range of abnormal conditions. Trainable, probabilistic, expandable.

- **Data assessment:** pattern recognition, intelligent systems, machine learning.

- **Diagnostics:** provides results & recommendations

*Source: Weatherford*
Stage 2

- Advances in sensors, data acquisition & storage, and diagnostics provide methods (tailored or generic) for improved well surveillance, intervention and planning.
Stage 3: Field Gas Lift Optimisation

- determine (and set) optimal gas rates for each well
- high frequency (daily) optimisation
- integrated asset model
- requires adequate infrastructure in instrumentation, metering, communications.
- implementation relies on adapting people & work processes.
- “Digital Oil Field”: i-Field, Smart Field, e-Field, etc.
Sustainable Production Optimisation

Optimisation gains revert to norm as system changes: automation of process is key to **sustain** the gains
Approaches to Field GL Optimization

Well Data

Deterministic Engineering Models

“Data Driven” Models

Well Behaviour

surveillance

real time optimisation

analysis
Generalised Online Real Time Optimisation (RTO) Architecture

SCADA* Systems

SCADA Interface

Data Management

Optimiser

Applications Manager

Data Driven or Deterministic Models

Model Export/Import

Offline Engineering Applications

Other Applications

Corporate Databases

3rd Party Interfaces

Internet/Intranet

*supervisory control and data acquisition
On Line GL Optimisation Examples

Ekofisk
Norwegian NS

Lobito Tomboco
Offshore Angola
Field Optimisation: Issues & Challenges

- Individual wells must already be optimised.
- Cost of implementation: brown fields?
- Increased data availability vs. decrease in engineering knowledge.
- Reliability, calibration & maintenance of SCADA and sensors -> unmanned offshore environment?
Stage 3

• Advances in SCADA, optimisation algorithms and data management have allowed gas lifted systems to be optimised on a relative high frequency cycle, resulting in increased oil production and more efficient lift gas usage.

• Real time/on-line gas lift optimisation is now a field proven methodology.
The Prize

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Conclusions

• The last decade has seen a step change in the understanding, surveillance, control and optimisation of the gas lift process:
  – GLV performance
  – Web based IT infrastructure
  – Optimisation algorithms & surveillance routines
  – SCADA and associated instrumentation

• Outstanding issues:
  – Measurement (notably Qgi)
  – Well testing
  – Maintenance
  – Training
Gas Lift may be robust and forgiving, however it can be improved with better applied engineering

Data Acquisition
Data Management
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