Single-Point Gas Lift Design Using Dynamic Simulation

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Single Point Injection Gas Lift

- Subsea General Issues
- Gas Lift Design Issues
- Subsea Gas Lift Design Issues
- Single Point Injection Issues
- Dynamic Simulation
- Understanding Slugging
- System Integration
- Surface Control GLVs
- Real-time Online Optimization
- Summary
Subsea General Issues

- Wells usually share flowline to platform:
  - FTHP cannot be considered constant
  - Over-injecting lift gas causes oil deferment

- Flowline/riser system is prone to slugging:
  - No validity of steady-state models
  - Difficult well kick off (risk of platform trip)

- Subsea wells are hardly ever surveyed (expensive access)
  - Long flowlines -> several hours stabilisation time ( > 8 hrs after GL rate change)
  - Slugging -> long test times
  - Difficult to test at normal operating conditions
  - Multi-rate testing of one well takes days

- Wells are sporadically tested (oil deferment)

- Downhole gauges/flowmeters are lacking/ malfunctioning
General Gas Lift Design Issues

Modeling concerns:

- **Stability**
  - Cause of Slugging

- **Annular Flow**
  - P-T gradients
  - Condensation (dry gas?)
  - Heading

- **Heat Transfer**
  - Counter-currents effects
  - T @ valve location

- **Non-Constant Fluid Composition in Tubing above Injection Point**

- **Unloading Valves Operation**

Gas Lift is clearly a transient system
Subsea Gas Lift Issues

• Zero Intervention Philosophy
  (High Cost Re-Entry / Impractical)
  – No unloading valves
    (no multi-point injection)
  – No re-entering to change GLVs
  – Orifice (no moving parts – higher life)

• Single Point Injection
  – Downhole
  – Wellhead
  – Riser
Single-Point Gas Lift Issues

- Stability (GL System Flexibility Lost)
  - Reduced operational range vs conventional GL: upper GLV injection can keep well in production and generating revenue (gone!)
  - Instability may be dampened due to multi-point injection in unloading GLVs (gone!)
  - Well-Riser Slugging Interaction (needs system integration)

- Significantly higher operating pressure is required to unload the well to this single depth.
Single-Point Gas Lift Issues

• No unloading GLVs may result in a shallower operating point and reduced draw-down – depending on compressor capacity economics

• If max injection pressure is already pre-selected, then: inj. depth variable. If not, inj. depth in well fixed as deep as possible, above 60° deviation – no limit for remote GLVs

• Once injection point is set, there is a minimum surface inj. rate required to maintain sufficient annular back pressure for continuous GL – it is a function of orifice size and flowing Ptubing (WHP, PI, reservoir pressure, watercut, etc.)
Subsea Single-Point Gas Lift Issues

- More Difficult Troubleshooting, Well Testing and Surveillance due to Subsea Environment and single point injection

- Dynamic simulation is necessary to properly design and operate subsea gas lift single point injection wells and systems due to the reduced system’s flexibility and range of application
Dynamic Simulation

- Prior to defining the gas-lift design, detailed flow assurance studies must be complete.

  For subsea and deepwater, the fluid behavior in the integrated well-flowline-riser system dictates the artificial lift design, not the wellbore environment itself.

- Dynamic Flow Assurance studies should include:
  - Stability analysis to determine P-T profiles, liquid hold-up and minimum gas / fluid velocities required for well-riser stability.
    - Well
    - Well-Flowline-Riser integrated system
  - Slugging Type & Severity (horizontal & deviated wells, riser):
    - Hydrodynamic slugging (slip induced)
    - Terrain induced slugging
Flow Assurance studies should include (cont.):

- **Optimum Injection Point and Gas Rate**: The primary cause of wellbore/flowline slugging is that the superficial gas velocity is too low. The addition of GL gas increases the superficial gas velocity, and changes the multiphase flow to a more stable flow regime.

- For high pressure gas lift scenarios, need to address:
  “Is the gas really a gas at the point of injection?”

- **Annulus/Inj. line**: Condensation could cause erosion of GLVs – eliminated by maintaining the temperature above condensation.

- In addition, issues regarding hydrates, wax, emulsions and other fluid behaviors must also be addressed.
Slugging
Slugging

Blue = Gas
Green = Oil
Red = Water
Gas Lift – One Injection Point
Example Setup

500 psia sep press

3 1/2”

5 1/2”

60°F

10000 ft

Choke at injection point

GOR = 500 scf/bbl

250°F, 3300 psia and 3 bbl/psi
Gas Lift – One Injection Point

Liquid Content

- Gas Lift Rate
- Liquid Content

Time [h]

Feb. 1 - 5, 2010

2010 Gas-Lift Workshop
Gas Lift – One Injection Point

BHP Pressure

Gas lift rate

BHP

Feb. 1 - 5, 2010

2010 Gas-Lift Workshop
Riser Gas Lift Stability

- Sever riser slugging occurs when liquid accumulates at the riser base and totally fill a section of the flowline and riser for an extended period of time under some flow conditions, especially when there is a downward slope in the flowline at the riser base and the flowrate is low.
Riser Gas Lift Stability
Severe Riser Slugging Mitigation

- Increase GL gas rate (no additional subsea equipment required)
- Reduction of flowline diameter and or riser diameter
- Gas injection in the riser
- Automatic flow rate control system
- Choking (reduce production capacity)
- Increase of backpressure (reduce production capacity)
- Splitting the flow into dual or multiple streams
- Use of mixing devices at the riser base
- Internal small pipe insertion (intrusive solution)
- External multi-entry gas bypass
- Internal coil tbg-packers in pipeline and riser
- External bypass line
- Subsea separation (2 separate flowlines and a liquid pump)
- Foaming (requires foaming agents and a way to form the foam)
**Integrated Modelling Application**

*Gas Lift Example*

*Reservoir-Well-GL-Flowline-Riser-Separator-Facilities*

- **Quasi-dynamic Reservoir:** incorporated explicitly
- **Facilities:** Simple model
Integrated Modelling Application
Gas Lift Example
Reservoir-Well-GL-Flowline-Riser-Separator-Facilities
Advantages Summary

- Higher reliability than conventional completion using unloading valves
- Meets “zero intervention” philosophy set for subsea developments
- Fewer expensive GL mandrels required (less relevant)
- Removal of moving parts or parts that could leak when using an orifice
- Eliminates risk of incorrect pressure settings on bellows (or inappropriate springs) and T effects
- Reduce the pressure differential require for a “hot start”.
Single Point Injection Using Orifice

Disadvantages Summary

- Less flexible design
- Less Range of Application
- Requires a minimum gas injection rate for well stability
- Requires a higher injection pressure
- Valve orifice erosion becomes an issue
- Operating valve may have to be set higher in the well (less production rate)
- A well with only one mandrel will require a major well intervention should the operating valve have a problem
- May require more expensive remote controlled GLV (less relevant)
Surface Controlled GLVs

• **Advantages**
  – Eliminates need for extensive orifice sizing
  – Reduces risk of erosion. Can remain “full open” during unloading and then close to necessary orifice size.
  – Orifice size can change as well conditions change without an intervention
  – Can be set deeper in the wellbore

• **Disadvantages**
  – Expensive (sometimes it is difficult to justify the cost of this system)
  – May require duplication (for risk reduction)
Real-Time Online Dynamic Simulation

• The stabilization of slugging GL wells is achieved by a dynamic feedback control solution using the production choke at the wellhead.
  – The primary input to the dynamic feedback controller normally is a measurement of the downhole pressure.
  – The injection choke port size can also be controlled.
  – A dynamic Simulator is critical to develop the control algorithm - SPE 56832

• Real-time Online dynamic simulator
  – Slug flow warning
  – Gas Lift Optimization Advisor
  – Virtual gauge and flowmeter
  – Erosion, Corrosion monitoring
  – Hydrate Advisor
  – MEG, MeOH inhibitor monitoring
  – Operator training simulator
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