Enhancing the Production Performance of Dual Completion Gas Lifted Wells using Venturi Orifice Valves

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Presentation Outline

• Introduction
• The Business Opportunity/Challenge
• Candidate Screening/Selection
• Nova vs Venturi Features/Benefits
• The Field Trial
• Well/System Challenges
• Results Discussion
• Conclusion
 ✓ Circa 70% of SPDC Gaslifted Wells are duals equipped with square edge orifice valves.

 ✓ Optimisation challenges and observed well instability.

 ✓ Deferment reduction associated with gas sharing challenges and inability to produce both arms of dual concurrently.

 ✓ Circa 9000 bopd was deferred during the period under review.
SHELL NIGERIA OPERATE PHASE DIMENSIONS

Challenges & Opportunities
- Large portfolio of producing and non-producing wells
- FTO issues and community disturbance
- Associated gas constraints
- Aging facilities
- Water production
- Sand production
- Impairment Water Injectors
- “Allowable” constraints
- Partner approval
- Straddling assets
- ...

SNEPCO
- 2 FPSOs (1 non-operated)
- 5 producing reservoirs
- 18 production wells
- 14 injection wells (x gas)
- Average prod. 10-50 bopd/ well
- Average inj. 60 bwpd/ well

SPDC
- 50 flowstations + 1 FPSO
- 602 producing reservoirs
- 1336 wells (31. NAG)
- 1402 drainage points
- Average 250 bopd/Conduit
- Ave. 58. MMscfd/ NAG well
The Niger Delta - A Large Portfolio of Oil and Gas Fields!
### NORTH FIELD – SUBSURFACE SNAPSHOT

<table>
<thead>
<tr>
<th>Discovery/1st oil: 1963/1965</th>
<th>10400 bopd @ at 64.6% BSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid type: NAG, AG/Oil</td>
<td>Drive Mechanism: Depletion drive, aquifer supported/water flood</td>
</tr>
<tr>
<td>60kbpd FS, 54MMscfd AGG Plant</td>
<td>66 Reservoir Blocks (5000 – 11000 ftss ) deep</td>
</tr>
<tr>
<td>Well Stock: 55 wells, 36 strgs on GL</td>
<td>Rsi – 300 – 1500 scf/bbl</td>
</tr>
</tbody>
</table>
NORTH Field Production Performance

- Open up and bean up to potential
- Peak production
- Decline – vertical lift problems (HBSW, HGOR & sand production)
- Bean back due to quota restrictions
- HZ + HZ ST drilling campaign

Start of gas lifting and water injection and drilling of new wells
Compressor reliability issues
Identified System & Well Challenges

- Inability to produce both arms of dual concurrently
- Gas Metering Challenges
- Well slugging
- Gas cycling
- Intermittent production
- Frequent compressor trips.
Square Edge Orifice Valve Challenges

1. Critical flow is attained with circa 40-50% downstream pressure. Difficult to achieve!
2. Non laminar flow. Turbulent flow around the square edge creates pressure losses hence difficult to achieve critical flow.
3. Large sub critical flow regime.
4. Slight variations in tubing flow regime results in large fluctuations in tubing pressure, injection rates, slugging and instability.
1. Computer generated profile to promote constant gas passage. It addresses key short comings of the traditional square edge orifice valve.
2. Flow profile (lamina) maximises gas passage with minimum differential.
3. Flow regime eliminates any effect of tubing pressure on gas injection rate.
4. Alleviates instability due to problems originating from the sub critical flow of liftgas across orifice valve;
   - Critical flow is attained with circa 10% diff between downstream and upstream pressure
   - Injection rates are constant when operating in critical flow. Fluctuation in tubing pressure does not affect injection volume.
   - Designed for fixed throughput.
5. Maintains deepest point of gas injection
6. Maximises efficiency, reduces cost and improves productivity.
Data Acquisition
Critical data: THP, CHP, Well test data

Establish Instability
Fluctuation: THP, CHP, Liquid rate, lift gas rate, CHP, Well test data

Analyse cause of instability
Poor Design, Over sized orifice, over injection

Establish Subcritical flow
Pt/Pc 0.6 - 0.9

STEP 1

STEP 2

STEP 3

STEP 4

STEP 5

STEP 6

Field Execution
1. Acquire fresh FG/BHP
2. Optimise design
3. Carryout GLVCO

Gaslift Design
Preliminary design using existing FG and Pressure
Candidate Screening Workflow/Criteria

CANDIDATE SCREENING AND SELECTION WORK FLOW

1. Analyse instability well
   - Pmp Pen chart
   - Pmr : Pen Chart
   - Qgi Pen Chart
   - GOR (well test)
   - Qo (well test)

2. Operations conditions

3. Calculate port diameter in function of Qgi, Ti, Pi, pi (in Injection point)

4. Put Nova valve in side pocket mandrel (with stick line)

5. Verify Well behaviour

6. Identify Causes of Instability
   - Correct
   - Quick win

7. Adjust Pmp modifying
   - Quick win

8. Trouble shoot well,
   - You detect suspect - Hole in the well, tubing/Injection point
   - WO or SL Int.

9. Adjust well model
   - Does well continue inject?
   - WO or SL Int.

10. Verify if port diameter is over size
    - Change port diameter with stick line

Legend
- Pmp = Well Head Pressure
- Pmr = Casing Pressure
- Qgi = Gas injection rate
- GOR = Gas oil ratio
- Qo = Oil rate
- Pt = Tubing Injection Point Pressure
- Pc = Casing injection point pressure
- T1 = Injection Point Temperature

Venturi Candidate Screening Workflow
Well Performance Expectation

FIG. 6a – Well 1 previous to the nozzle-Venturi valve installation.

FIG. 6b – Well 1 after the installation of the nozzle-Venturi valve.
Well was reported to have lift gas sharing issues.

Both strings could not produce concurrently.

Long string was **produced** preferential to the short string.

Selected for NOVA™ pilot trial.

Post nodal analysis and redesign, the Orifice depth was optimized from 4577 to 3626 ft along hole.

The orifice depth on the short string was optimized from 4107 to 3597 ft along hole.

**OBIGBO 08 MANDREL DEPTHS (FT ALONG HOLE)**

<table>
<thead>
<tr>
<th>LONG STRING</th>
<th>SHORT STRING</th>
</tr>
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<tbody>
<tr>
<td>1984 Valve</td>
<td>1947 Valve</td>
</tr>
<tr>
<td>2953 Valve</td>
<td>2985 Valve</td>
</tr>
<tr>
<td><strong>3626 NOVA™</strong></td>
<td><strong>3597 NOVA™</strong></td>
</tr>
<tr>
<td>4577</td>
<td>4107</td>
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Results – Well O002L Performance Pre and Post installation

Prior Nova deployment

Post Nova deployment
Results – Well O002L Performance > 8 Months after
Results – Well O001L Performance 1 Month Post installation
Results: Well O001L Performance 8 Months Post Installation
Results – Well O002S Performance Post Installation

![Graph showing well performance data post-installation.](image-url)
Results: Well O002S Performance 8 Months Post Installation
Results – Well Performance Post Pre vs Post Nova
Results – Well A2S Performance Post Pre vs Post Nova
## Results – Well A2S Performance Post Pre vs Post Nova

<table>
<thead>
<tr>
<th>Date</th>
<th>THP</th>
<th>Bean 64ths</th>
<th>Liquid bbl/d</th>
<th>WC (%)</th>
<th>Oil bbl/d</th>
<th>Calculated Gas Lift Rate MMscf/d</th>
<th>GOR Scf/bbl</th>
<th>Comment</th>
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<tbody>
<tr>
<td>9-Jan-12</td>
<td>220</td>
<td>52</td>
<td>685</td>
<td>54</td>
<td>310</td>
<td>1.7</td>
<td>737</td>
<td>Post Nova</td>
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<tr>
<td>26-Dec-11</td>
<td>221</td>
<td>52</td>
<td>683</td>
<td>52</td>
<td>322</td>
<td>1.7</td>
<td>605</td>
<td>Post Nova</td>
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<td>25-Dec-11</td>
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<td>52</td>
<td>666</td>
<td>52</td>
<td>315</td>
<td>1.7</td>
<td>531</td>
<td>Prior Nova</td>
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<tr>
<td>12-Dec-11</td>
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<td>52</td>
<td>259</td>
<td>52</td>
<td>122</td>
<td>1.4</td>
<td>920</td>
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<tr>
<td>4-Nov-11</td>
<td>120</td>
<td>52</td>
<td>256</td>
<td>52</td>
<td>121</td>
<td>1.5</td>
<td>78</td>
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<tr>
<td>12-Oct-11</td>
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<td>52</td>
<td>256</td>
<td>52</td>
<td>121</td>
<td>1.8</td>
<td>579</td>
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<thead>
<tr>
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<th>THP</th>
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<th>Calculated Gas Lift Rate MMscf/d</th>
<th>GOR Scf/bbl</th>
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<td>2-Jan-12</td>
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<td>60</td>
<td>330</td>
<td>32</td>
<td>229</td>
<td>1.2</td>
<td>375</td>
<td>Post Nova</td>
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<tr>
<td>28-Dec-11</td>
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<td>60</td>
<td>342</td>
<td>32</td>
<td>231</td>
<td>1.9</td>
<td>295</td>
<td>Post Nova</td>
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<tr>
<td>5-Nov-11</td>
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<td>60</td>
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<td>28</td>
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<td>1.7</td>
<td>338</td>
<td>Prior Nova</td>
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<tr>
<td>22-Oct-11</td>
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<td>60</td>
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<td>37</td>
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<td>491</td>
<td>Prior Nova</td>
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<td>23-Aug-11</td>
<td>108</td>
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<td>352</td>
<td>44</td>
<td>196</td>
<td>1.7</td>
<td>710</td>
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**Figure 5b**—Well A2S 8 months after venturi data acquisition.
Results – Well F L/S Performance Pre and Post Venturi

<table>
<thead>
<tr>
<th>Interval</th>
<th>Pre GLVCO</th>
<th>Post GLVCO</th>
<th>Oil Gain</th>
<th>Remarks</th>
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<tbody>
<tr>
<td></td>
<td>Potential (bopd)</td>
<td>Actual Prod (bopd)</td>
<td>Potential (bopd)</td>
<td>Actual Prod (bopd)</td>
</tr>
<tr>
<td>F114L</td>
<td>888</td>
<td>195</td>
<td>238</td>
<td>238</td>
</tr>
<tr>
<td>F114S</td>
<td>97</td>
<td>0</td>
<td>149</td>
<td>149</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Remarks
- Interval closed in prior to GLVCO
Key Learning’s and Recommendations

✓ Real Time optimisation of designs was key to a successful implementation.
✓ NOVA Orifice valve is not a silver bullet as not all wells with gas sharing challenge require a NOVA solution
✓ Inability of one arm of a dual gas lifted well to produce is not necessarily due to gas-sharing issues. Poor gas lift design has been identified as the cause in some cases.
✓ Choke size of the venturi orifice needs to be carefully designed and sized to enable passage of optimal amount of lift gas.
✓ Candidates must be carefully screened and a case for gas sharing clearly established to enable benchmark of well performance after venturi installation.
✓ CHP and THP profile(s) of the candidate well(s) should be recorded for reasonable length of time especially after venturi installation as stability in tubing and casing pressure can only be evident once critical flow is established.
✓ Suboptimal lift gas injection and low injection pressures can cause instability and non production of gas lift conduits.
✓ Venturi orifice valve can stabilize production from previously unstable wells by attaining critical flow much earlier than with conventional orifice.
Conclusion/Go Forward Plans

✓ Venturi orifice valve installation in the carefully selected candidate wells stabilised well production and reduced well instability significantly.

✓ The Venturi installation improved the efficiency of all the 4 pilot wells (8 strings), improved stability, restored concurrent production and optimised gas injection rate.

✓ Circa 700 bopd was restored and sustained in the last 1yr+.

✓ Standardise on the Venturi and replace all installed BKF6 Valves at earliest opportunity

✓ Roll out in other fields
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