Lift with Gas from Offset Well and its Application

CNPC Gas Lift Center

June, 2018
1. Preface

Lift with gas from offset well follows principle of continuous gas lift. For block with high pressure gas well, the HP gas well is used to replace compressor as source of lift gas for production. No need for construction of surface gas boosting system and investment can be saved significantly.
In order to satisfy gas lift production, wellhead tubing pressure of gas well must not be smaller than oil well gas injection pressure and the gas volume must not be smaller than the gas demand of oil well.
2. Analysis on lift with gas from offset well

Technical thinking:

1. Gas well and oil well should be taken as one system for integrated consideration;

2. The production rate of oil well is taken as target and the choke of gas well is taken as node. The production characteristics of oil and gas wells are analyzed respectively and then a coordination point is to be achieved, so that the gas injection pressure and injection rate of oil well can be obtained;

3. As per oil well target oil rate, gas injection pressure, and gas injection rate, the gas lift process design and gas well production system design shall be conducted.
2. Analysis on lift with gas from offset well

1. Analysis of oil well

Oil rate of producer is taken as target to obtain the oil well gas lift response characteristics curve and achieve the required gas injection rate under different gas injection pressures.

Under different gas injection pressures, in order to achieve expected oil rate, the required gas injection rate increases with the decrease of gas injection pressure.
2. Analysis on lift with gas from offset well

1. Analysis of oil well

According to the required gas injection rate for different gas injection pressures, the relationship plot between gas injection pressure and gas injection rate can be obtained. This plot is the critical condition that oil well can achieve the expected target oil rate.
2. Analysis on lift with gas from offset well

2. Analysis of gas well

According to the gas well production status, the wellhead tubing pressure and gas production rate of gas source well shall be obtained.

Oil rate decreases with the increase of wellhead tubing pressure.
3. Analysis and reckoning

To obtain the relationship plot of wellhead tubing pressure vs. gas production rate of gas source well

To obtain the relationship plot of gas injection pressure and gas injection rate of oil well and achieve the range of gas injection pressure and gas injection rate that satisfies oil well production

Under the same coordinates, two plots shall be produced and analysis shall be made based on the relative location relationship.
2. Analysis on lift with gas from offset well

Scenario 1:

If the plot of wellhead pressure vs. gas rate of gas well is all above plot of gas injection pressure vs. gas injection rate of oil well, the gas lift production of oil well under expected oil rate can be realized.
2. Analysis on lift with gas from offset well

If the plot of wellhead pressure vs. gas rate of gas well is partially above plot of gas injection pressure vs. gas injection rate of oil well, the gas lift production of oil well under expected oil rate can be realized; or production of oil well under expected oil rate cannot be realized.

Scenario 2:
2. Analysis on lift with gas from offset well

Scenario 3:

If plot of wellhead pressure vs. gas rate of gas well is all under plot of gas injection pressure vs. gas injection rate of oil well, the gas lift production of oil well under expected oil rate cannot be realized.
2. Analysis on lift with gas from offset well

- By using the plot of gas well and oil well, the max. oil rate of oil well can be obtained to guide the oil well production allocation.

![Diagram showing max. allowed oil rate](image)
2. Analysis on lift with gas from offset well

- With the decrease of formation pressure of gas well, the gas well production characteristics plot moves downward till there is only one intersection. At this point, the corresponding formation pressure is the lowest pressure that gas well satisfies oil well production. Based on the prediction of the variation of formation pressure of gas well, the production cycle of lift with gas from offset well can be obtained.
2. Analysis on lift with gas from offset well

△ The freeze blockage can be analyzed by using the relationship plot of gas source well and oil well. The oil well gas injection pressure under the optimally selected oil rate could guarantee under such pressure condition, the hydrate formation temperature is lower than the environment temperature so as to avoid the freeze blockage of surface gas supply pipeline.

Prediction of hydrate formation
3. Supporting processes

1. Oil well design
   - GLV deployment

   The design of process parameters for gas lift valve deployment for the lift with gas from offset well is the same as boosting continuous gas lift production.

   The calculation method or professional gas lift software can be used.
3. Supporting processes

1. Oil well design

◆ Design of completion string

Usually semi-closed completion string is used, which could avoid the gas injection pressure being applied to formation, to guarantee well perform of the oil well capacity.

Commonly used downhole tools:

<table>
<thead>
<tr>
<th>SN</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gas lift valve</td>
<td>to realize oil well unloading and gas injection production</td>
</tr>
<tr>
<td>2</td>
<td>Mandrel</td>
<td>to install gas lift valve</td>
</tr>
<tr>
<td>3</td>
<td>Sliding sleeve</td>
<td>Provide circulating channel for tubing and annulus to realize well flushing and kill operation</td>
</tr>
<tr>
<td>4</td>
<td>Packer</td>
<td>Separate oil zone and upper casing and tubing annulus, avoid high pressure gas contacting reservoir directly and decrease impact on oil well production</td>
</tr>
</tbody>
</table>
3. Supporting processes

1. Oil well design

- Surface process design

For lift with gas from offset well, usually reconstruction of oil well surface flow is needed to adapt to gas lift production

- 1--gas metering & adjustment devices
- 2,3--gate valve, used for change and control direction of gas supply
- 4--pressure gauge to record wellhead casing pressure during lift operation

Schematic of surface flow for lift with gas from offset well
3. Supporting processes

2. Gas well design

◆ Design of surface choke

Usually, for lift with gas from offset well, throttling devices such as choke or needle valve shall be installed at wellhead of gas well to achieve the gas injection pressure and volume demanded by oil well gas lift production. The diameter of choke can be calculated or based on professional software result.
3. Supporting processes

2. Gas well design

◆ Design of bottomhole choke

The source gas of lift with gas from offset well is untreated gas and it is prone for the formation of hydrate after surface throttling, leading to the freeze of gas supply pipeline.

<table>
<thead>
<tr>
<th>Choke size (mm)</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>T before choke (℃)</td>
<td>11</td>
<td>15</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>T after choke (℃)</td>
<td>-46</td>
<td>-41</td>
<td>-36</td>
<td>-30</td>
</tr>
<tr>
<td>T difference before and after choke (℃)</td>
<td>-57</td>
<td>-56</td>
<td>-55</td>
<td>-55</td>
</tr>
</tbody>
</table>
2. Gas well design

◆ Design of downhole choke

Downhole choke throttling technology is adopted. Downhole choke is installed at appropriate point of tubing. Throttling is transferred from surface to wellbore to increase wellhead gas temperature and the surface freezing problem is effectively solved.

3. Supporting processes
4. Application performance

1. X Oilfield in Africa

- Production status of oil well before gas lift

<table>
<thead>
<tr>
<th>Well no.</th>
<th>Oil zone mid-depth (m)</th>
<th>Formation pressure (Mpa)</th>
<th>FBHP before experiment (MPa)</th>
<th>Oil rate before experiment (bbl/d)</th>
<th>Production status</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX-17</td>
<td>1880</td>
<td>15.67</td>
<td>15</td>
<td>151</td>
<td>flow ends</td>
</tr>
<tr>
<td>XX-59</td>
<td>2012</td>
<td>17.94</td>
<td>17</td>
<td>319</td>
<td>weak flow</td>
</tr>
</tbody>
</table>

- Production status of gas source well

<table>
<thead>
<tr>
<th>Well no.</th>
<th>Oil zone mid-depth (m)</th>
<th>Formation pressure (Mpa)</th>
<th>Formation temperature (℃)</th>
<th>Gas rate (m³/d)</th>
<th>Oil rate (m³/d)</th>
<th>Water cut</th>
<th>Wellhead tubing pressure (MPa)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX-27</td>
<td>2292</td>
<td>21.23</td>
<td>87.8</td>
<td>234,764</td>
<td>13.04</td>
<td>0</td>
<td>17(shut in)</td>
<td>frequent freezing</td>
</tr>
</tbody>
</table>
4. Application performance

- Technical measures for anti-freeze for downhole choke of Well XX-27

- Design depth: 1500m
- Downhole nozzle: 13mm
- Gas rate: $20 \times 10^4$ m$^3$/d
- Wellhead tubing pressure: 12MPa
- Wellhead temperature: 35°C, no freeze
After the implementation of lift with gas from offset well in 2011 for Well XX-17 and Well XX-59, the oil rates increased from 24.0 m$^3$/d and 50.7 m$^3$/d to 218 m$^3$/d and 369 m$^3$/d respectively, an increase of 8 and 6 folds.

### 4. Application performance

#### 1. X Oilfield in Africa

After the implementation of lift with gas from offset well in 2011 for Well XX-17 and Well XX-59, the oil rates increased from 24.0 m$^3$/d and 50.7 m$^3$/d to 218 m$^3$/d and 369 m$^3$/d respectively, an increase of 8 and 6 folds.
2. **X Oilfield in Mid-Asia**

2015-2016, applied totally for 42 well times. Average single well oil incremental 21.25t/d and cumulatively surface investment was saved by USD 17 million.

<table>
<thead>
<tr>
<th>SN</th>
<th>Well no.</th>
<th>Liquid rate (t/d)</th>
<th>Oil rate (t/d)</th>
<th>Water cut (%)</th>
<th>GOR (m³/t)</th>
<th>Liquid rate (t/d)</th>
<th>Oil rate (t/d)</th>
<th>Water cut (%)</th>
<th>GOR (m³/t)</th>
<th>Comparison Liquid incremental (t/d)</th>
<th>Comparison Oil incremental (t/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7639</td>
<td>0</td>
<td>32</td>
<td>1</td>
<td>32</td>
<td>0.3</td>
<td>32</td>
<td>0.3</td>
<td>890</td>
<td>32</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>5578</td>
<td>0</td>
<td>20</td>
<td>0.7</td>
<td>20</td>
<td>0.0</td>
<td>20</td>
<td>0.0</td>
<td>977</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>7570</td>
<td>0</td>
<td>31</td>
<td>55</td>
<td>36</td>
<td>0.2</td>
<td>547</td>
<td>547</td>
<td>1074</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>7545</td>
<td>0</td>
<td>21</td>
<td>0.5</td>
<td>36</td>
<td>1.3</td>
<td>1090</td>
<td>1090</td>
<td>1294</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>7669</td>
<td>0</td>
<td>14</td>
<td>3</td>
<td>25</td>
<td>23.0</td>
<td>1294</td>
<td>1294</td>
<td>1294</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>7871</td>
<td>15</td>
<td>14</td>
<td>358</td>
<td>25</td>
<td>23.0</td>
<td>1294</td>
<td>1294</td>
<td>1294</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>7546</td>
<td>15</td>
<td>14</td>
<td>21</td>
<td>15</td>
<td>1.3</td>
<td>1090</td>
<td>1090</td>
<td>1294</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>CT-45</td>
<td>0</td>
<td>24</td>
<td>33</td>
<td>24</td>
<td>0.0</td>
<td>364</td>
<td>364</td>
<td>364</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>601</td>
<td>0</td>
<td>31</td>
<td>54.3</td>
<td>24</td>
<td>51.8</td>
<td>249</td>
<td>249</td>
<td>249</td>
<td>31</td>
<td>15</td>
</tr>
<tr>
<td>10</td>
<td>566</td>
<td>6</td>
<td>31</td>
<td>15</td>
<td>31</td>
<td>15</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>11</td>
<td>7675</td>
<td>20</td>
<td>41</td>
<td>6</td>
<td>34</td>
<td>0.2</td>
<td>188</td>
<td>188</td>
<td>188</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>12</td>
<td>7640</td>
<td>20</td>
<td>41</td>
<td>58</td>
<td>34</td>
<td>0.1</td>
<td>188</td>
<td>188</td>
<td>188</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>13</td>
<td>498</td>
<td>17</td>
<td>34</td>
<td>62.2</td>
<td>17</td>
<td>31</td>
<td>459</td>
<td>459</td>
<td>459</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>14</td>
<td>719</td>
<td>3</td>
<td>34</td>
<td>1254</td>
<td>17</td>
<td>31</td>
<td>459</td>
<td>459</td>
<td>459</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>H519</td>
<td>30</td>
<td>35</td>
<td>369</td>
<td>30</td>
<td>35</td>
<td>369</td>
<td>369</td>
<td>369</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>41</td>
<td>7548</td>
<td>0</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>8.32</td>
<td>1258</td>
<td>1258</td>
<td>1258</td>
<td>11</td>
<td>8.32</td>
</tr>
<tr>
<td>42</td>
<td>7865</td>
<td>9</td>
<td>35.8</td>
<td>17</td>
<td>17</td>
<td>30.3</td>
<td>1242</td>
<td>1242</td>
<td>1242</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

**Average** 21.25
5. Conclusions

- Lift with gas from offset well could realize gas lift production when gas boosting system is not available. The field construction can be accelerated and the surface system investment can be lowered.

- The method for lift with gas from offset well is formed. The feasibility of lift with gas from offset well can be judged. The core process parameters including oil rate, gas injection pressure and injection rate of oil well can be determined.

- The maximum oil well rate, gas lift service life and surface freezing etc. can be effectively predicted.

- The main constraint of lift with gas from offset well is the wellhead tubing pressure and gas production rate of gas well, therefore, it is of great importance to predict the gas rate and pressure variation of gas source well.
THANKS!