Standardized Mobile Wellhead Compressor for Onshore Gas Wells in The Netherlands

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Outline

• Background of Nederlandse Aardolie Maatschappij BV (NAM), Onshore gas, Netherlands
• The game of deliquification in NAM Onshore
• Portfolio review - defining a business case for Mobile Wellhead Compression (MWHC)
• Deriving design parameters for a generic MWHC
• The next step – integration with gas lift
NAM is a joint venture, shareholders Shell (50%) and ExxonMobil (50%).

~90 producing fields
~270 producing wells via 26 treatment facilities
The game of deliquification in NAM Onshore
Deliquification & ‘depressurization’ techniques

- Increase gas velocity (e.g. velocity string or gas lift)
- Reduce critical velocity (e.g. foam injection)
- Artificially lift water (e.g. downhole pump or plunger)
- Reduce tubing pressure (e.g. third stage compressor)
Deliq operating envelope

MWHC PERFORMANCE CURVES

- Typical min. suction pressure 2-stage compressor (12 bara)
- Additional reserves
- Discharge 12 bara
- Operating area foam injection
- Liquid loading line

Flow rate Q (km³/day)

Tubing pressure (bara)
Project objective

“Maximize recovery of mature low-pressure fields by lowering the THP preventing the well to liquid load and preventing back-out”

Build a comprehensive portfolio

I. Settle on universal design conditions
II. Recognize interaction with other (deliquification) developments

STANDARDISE

I. Define ‘generic’ BfD
Portoflio review

• Defining a business case for Mobile Wellhead Compression (MWHC)

• Consider the lifecycle of deliq methods
Discharge pressure – initial capacity compressor
Discharge pressure – initial capacity compressor

With manifold solutions less compressors are needed

54 possible single wells

28 possible single wells + manifolds
Choice of deliq methods

Compression (CO) – in all cases, recovers the most significant volumes
Continuous Foam (CF) – complementary to compression (although not technically desirable due to foaming)
Gas lift (GL) – complementary to compression

Ultimate recovery
Deriving design parameters for a generic MWHC

• A generic design that meets 80-20 rule
Fthp – minimum rate (@ Liquid loading)

West & North production systems

Fthp – minimum rate (@ Liquid loading)

Tube ID ≈ 3 in
Tube ID ≈ 4 in
Tube ID ≈ 6 in

Max discharge pressure = 20 bara

FTHP (NFA @ LL) - Qmin (NFA @ LL)

Qmin Deliq [10^3 m^3/d]
Ft ht – minimum rate (@ Liquid loading)

West & North production systems

FTHT (NFA @ LL) - Qmin (NFA @ LL)

Max inlet temperature = 60 °C
Defining liquid capacity

Where to draw the line? What about possible formation water breakthrough in the future?
LGR limit per possible MWHC candidates

Max LGR = max liquid rate/rate

Max rate = 420 kNm^3/d

The comfort factor
Slug size

Theoretical slug sizes

Key parameters:
- Tubing ID $^2$
- Difference in CITHP and FTHP

Designed for: 1 m$^3$ produced within minutes.

Matches (limited) field data
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Abbreviation</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed in tubing wellhead pressure</td>
<td>CITHP</td>
<td>≤80</td>
<td>barg</td>
</tr>
<tr>
<td>Flowing tubing wellhead pressure</td>
<td>FTHP</td>
<td>≤12</td>
<td>barg</td>
</tr>
<tr>
<td>Max. skid inlet temperature</td>
<td>FTHT</td>
<td>≤60</td>
<td>°C</td>
</tr>
<tr>
<td>Max. skid outlet temperature</td>
<td></td>
<td>≤80</td>
<td>°C</td>
</tr>
<tr>
<td>Overall liquid rate</td>
<td></td>
<td>50</td>
<td>m3/d</td>
</tr>
<tr>
<td>Slug size (instantaneous; within 1 min.)</td>
<td>S</td>
<td>1.0</td>
<td>m3</td>
</tr>
<tr>
<td>Number of slugs at start-up</td>
<td></td>
<td>1x</td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide content</td>
<td>CO2</td>
<td>10</td>
<td>mol%</td>
</tr>
<tr>
<td>Hydrogen sulfide content</td>
<td>H2S</td>
<td>0.5</td>
<td>mbar</td>
</tr>
<tr>
<td>Sand (continuous production)</td>
<td></td>
<td>≤0.2</td>
<td>kg/mln.Nm3</td>
</tr>
<tr>
<td>Oil carry-over</td>
<td></td>
<td>≤5</td>
<td>ppm</td>
</tr>
<tr>
<td>Corrosion inhibitor content</td>
<td></td>
<td>≤1000</td>
<td>ppm</td>
</tr>
</tbody>
</table>
## Concept table third stage compression

<table>
<thead>
<tr>
<th></th>
<th>Centrifugal</th>
<th>Reciprocating</th>
<th>Rotary screw</th>
<th>Gas Jack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (mln.Nm³/d)</td>
<td>&gt;10</td>
<td>0.05-10</td>
<td>0.01-1.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Min. suction pressure (bara)</td>
<td>&gt;10</td>
<td>3-4</td>
<td>1.1-5</td>
<td>1.1</td>
</tr>
<tr>
<td>Max. discharge pressure (bara)</td>
<td>200</td>
<td>100-300</td>
<td>20-50</td>
<td>20</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>1.2-1.5 per impeller</td>
<td>2-4 per stage</td>
<td>2-10</td>
<td>2-20</td>
</tr>
</tbody>
</table>

### Advantages
- High capacity
- Medium/high efficiency
- 2-Stage machines offer high efficiency
- High discharge pres.
- Low CAPEX (1-stage)
- Sour gas solution
- Wide operating range
- High compression ratio
- Capable of handling various gas compositions
- Low/medium CAPEX and maintenance cost
- Simple design
- High compression ratio
- Capable of handling various gas compositions
- Low CAPEX

### Disadvantages
- High CAPEX
- Narrow operating range e.g. flexibility
- Specialized maintenance & control
- High maintenance cost e.g many moving parts
- Each unit is designed for a specific gas comp.
- Low adiabatic efficiency
- Short life expectancy
- Noise
- Low capacity
- Not following Shell DEP/DEMs
- Noise and vibrations
- EU regulations
MWHC Functional modules

1. Pre treatment
   Optional: Sand/Foam/Large slugs

2a. Slug handling & liquid separation

2. Slug handling & liquid separation (small)

3. Compression

4. Fluid mixing

5. Oil processing

6. Liquid pumping

7. Air cooling

8. Power supply

SKIDDABLE
"PLUG AND PLAY"
Process flow scheme MWHC

MOBILE WELLHEAD COMPRESSION
OIL-FLOODED SCREW COMPRESSOR (HOWDEN 255-193)

Design life MWHC skid = 25 years
Compressor performance curves

Operating envelope MWHC

- Discharge = 20 bara
- Discharge = 12 bara

Compressor load
- 20%
- 40%
- 60%
- 80%

Suction pressure (bara)

Flow rate (Nm3/d)
Next steps.....gas lift

Well performance curves

with compression and gas lift

only gas lift

Tubing Head Pressure vs FlowRate

ΔP

FlowRate (10^3 m³/d)

Tubing Head Pressure (bar)

2014 Gas Well Deliquification Workshop Denver, Colorado
Gas lift with MWHC

Gas lift recovers more than continuous foam

Gas lift with wellhead compression (2bara) recovers 30% more
Gas lift with MWHC

Technical work to be done

Retrofit
Straddle to maintain well barrier.
Completions:
\[\geq 4 \frac{1}{2} \text{和完善} \]
\[\leq 3 \frac{1}{2} \text{和完善} \]

Workover is cost prohibitive

Well operating envelope:
Corrosion – wet gas

With SPM
Conclusions

Conclusions and Achievements:
Bottom-up approach proved to be successful. Analysis enabled by simple screening tool to analyse many wells

Parameters for MWHC for Basis for Design delivered

Gas Lift and Continuous Foam not an alternative to MWHC

Gas Lift to be preferred to Continuous Foam with MWHC

Next steps:
Design specific solutions or alternative compressors for wells outside of current MWHC operating envelope

Subsurface retro-fit solution to enable gas lift
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