Maximize artificial lift systems reliability due to continuous in-house failure analysis and optimization

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Michael Nirtl
Aberdeen, 13. June 2018
Agenda

- Introduction
  - OMV Austria
  - Artificial lift systems
- Failure analysis
- Optimization
  - Sucker rod pump
  - Electrical submersible pump
- Results
- Summary
Introduction
OMV Austria

- Production ~28,000 boe/day
- 10% of the Austrian oil and gas demand
- 50 fields
- 600 employees
- Technology center of OMV group
- 120 WI per year

![Pie chart showing the distribution of oil wells (700), gas wells (165), water injectors (90), and storage (115).]
Introduction
Artificial Lift Systems

Depth vs. rate
Gross production [bbl/d]

Pump / Installation setting depth [ft]

SRP
Continuous GL
Intermittent GL
ESP

Ref: ISBN 978-3-941721-86-9
Failure Analysis Information

Root cause
- Tubing string
- Sucker rod string
- SRP downhole pump
- Reservoir

Equipment inspection
- Tubing string measurement
- Sucker rod string inspection
- Downhole pump disassembly

Pull report
- Worn rod guides
- Paraffin deposition
- Sand
- Scale
- Hole in tubing

Change in production
- Dynamometer
- Liquid level
- Tubing integrity
- Separator test
- Sand, gas, WC trend
Failure Analysis Documentation

Artificial Lift System

ALS Subsystem

Equipment

Cause

Primary Cause

Severe

Moderate
Optimization SRP Equipment

SRP subsystem
- SRP downhole pump: 57%
- Tubing string: 29%
- Sucker rod string: 14%

SRP downhole pump
- Valve: 11%
- Barrel: 19%
- Seating assembly: 6%
- Plunger: 43%
- Valve rod: 3%
- On/Off tool: 18%
# Optimization SRP Equipment and Cause

## SRP downhole pump failure causes

<table>
<thead>
<tr>
<th>Cause</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion body hole</td>
<td>21</td>
</tr>
<tr>
<td>Corrosion thread</td>
<td>1</td>
</tr>
<tr>
<td>Corrosion body hole</td>
<td>3</td>
</tr>
<tr>
<td>Grooves</td>
<td>8</td>
</tr>
<tr>
<td>Stuck pump</td>
<td>5</td>
</tr>
<tr>
<td>Connection assembly worn out</td>
<td>3</td>
</tr>
<tr>
<td>Unscrewed</td>
<td>1</td>
</tr>
<tr>
<td>Abrasion rod guide</td>
<td>3</td>
</tr>
<tr>
<td>Abrasion seating assembly</td>
<td>12</td>
</tr>
<tr>
<td>Abrasion seating assembly and unscrewed</td>
<td>2</td>
</tr>
<tr>
<td>Tag-bottom</td>
<td>10</td>
</tr>
<tr>
<td>Unscrewed</td>
<td>3</td>
</tr>
<tr>
<td>Abrasion standing valve</td>
<td>27</td>
</tr>
<tr>
<td>Abrasion standing valve and lower traveling valve</td>
<td>14</td>
</tr>
<tr>
<td>Abrasion traveling valve</td>
<td>16</td>
</tr>
<tr>
<td>Blocked by sand</td>
<td>3</td>
</tr>
<tr>
<td>OMV connector torn</td>
<td>2</td>
</tr>
<tr>
<td>Unscrewed</td>
<td>5</td>
</tr>
<tr>
<td>Break thread</td>
<td>4</td>
</tr>
</tbody>
</table>

## RCFA

- **Barrel**
- **Plunger**
- **On/Off tool**
- **Seating assembly**
- **SRP downhole pump**
- **Valve**
- **Valve rod**

**Artificial Lift System**

**ALS Subsystem**

**Equipment**

- **Primary Cause**
- **Severe**
- **Moderate**

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8 | OMV Upstream, Kometer Bernd, 4 July 2018

Ref: SPE-190958-MS
Optimization SRP
Root Cause Failure Analysis

OMV TECH Center & Lab & AC²T research

- Barrel: Honing scratches in chromium layer as starting point for corrosion
- Plunger: Quality and thickness of spray metal coating
- Improved OMV Specification for SRP and quality assurance by factory acceptance tests
- Valve
  - Valve deformation main driver
  - No corrosion detected
  - No erosion by dispersed sand
  - No sand particles embedded

Ref: SPE-190958-MS
## Optimization SRP Customization

### SRP downhole pump

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Seating assembly</th>
<th>Barrel</th>
<th>Valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure cause</td>
<td>Abrasion rod guide</td>
<td>Abrasion seating assembly</td>
<td>Corrosion body hole</td>
</tr>
<tr>
<td>Failure reason</td>
<td>Valve rod movement in deviated well</td>
<td>Corrosion and abrasion</td>
<td>Sand</td>
</tr>
<tr>
<td>Solutions</td>
<td>Spiral rod guide to stabilize valve rod</td>
<td>Brass barrel</td>
<td>Full flow cage</td>
</tr>
</tbody>
</table>

### SRP downhole pump

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Valve rod</th>
<th>Plunger</th>
<th>Lower travelling valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure cause</td>
<td>Unscrewed</td>
<td>Stuck plunger</td>
<td>Hole in valve cage</td>
</tr>
<tr>
<td>Failure reason</td>
<td>Tag bottom</td>
<td>Sand</td>
<td>Gas</td>
</tr>
<tr>
<td>Solutions</td>
<td>Collet type valve rod bushing</td>
<td>FARR™ plunger</td>
<td>Gas lock breaker heavy ball and seat</td>
</tr>
</tbody>
</table>
Optimization ESP
ALS Subsystem

ESP subsystem failure frequency

- Motor: 36%
- Gas separator: 7%
- Pump: 29%
- Cable: 21%
- Intake: 7%

Artificial Lift System

ALS Subsystem

Equipment

Cause

Primary Cause

Severe

Moderate
Optimization ESP
Equipment and Condition Monitoring

Gas Separator

- bearing
- shaft
- housing

Primary cause:
- severe
- moderate

Ref: ISBN 978-3-941721-86-9
Optimization ESP Gas Separator
Optimization ESP Equipment and Condition Monitoring

Pump

- shaft
- bearing
- diffusers
- impeller
- housing

Artificial Lift System

ALS Subsystem

Equipment

- Cause
  - Primary Cause
  - Severe
  - Moderate

Moderate severe primary cause
Optimization ESP Pump

Ref: Schlumberger
Optimization ESP Customization

- Pump
  - Mixed flow
  - 1 tungsten carbide bearing per ft
  - Compression pumps
- Intake
  - Change from gas separator to intake
  - Tungsten carbide bearings
- Protectors
  - Tandem protector with up to 6 seals
- Motor
  - Single motor
- Cable
  - Lead cable with factory spliced MLE
Results
SRP Downhole Pump - Failure Recurrence Index

\[
\text{Failure recurrence index} = \frac{\sum \text{Equipment failures}}{\sum \text{ALS subsystem failures}}
\]

Artificial Lift System

ALS Subsystem

Equipment

Cause

Primary Cause

Severe

Moderate
Results
SRP - Mean Time Between Failures

Normalized MTBF moving average

MTBF improvement [%]

01.01.2016  01.04.2016  01.07.2016  01.10.2016  01.01.2017  01.04.2017  01.07.2017  01.10.2017
Results
SRP - Life Cycle Cost

Total life cycle cost and break even point analysis

- Total LCC and BEP
- Well intervention cost increase

- Total LCC runlife increase 10%
- Total LCC runlife increase 50%
- BEP low oil

Ref: SPE-190958-MS
In-house failure analysis serves as the fundament for continuous artificial lift system optimization

Quality assurance by factory acceptance tests at the pump manufacturer and laboratory inspection of failed parts ensures high quality of equipment

Root cause failure analysis is a vital method to mitigate severe and recurring problems

Economics: Increase of runlife leads to a decreasing amount of well interventions thereby decreasing life cycle costs

Shift from standardization to customization of equipment for specific well conditions
References

- SPE-190958-MS (August 2018)
- SPE-185770-MS
- ISBN 978-3-941721-86-9
- API RP 11S1
- API 11AX
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