Practical Workflows for Reservoir Management and Production Enhancement in Fields under Waterflooding

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1. Sabriyah Field Overview

6 Complex Heterogeneous Reservoirs, ~3000 ft Gross Thickness, >600 Active Wells

SA Production Contribution by Reservoir

- Upper Burgan: 15%
- Lower Burgan: 22%
- Moudud: 58%
- Minor Reservoirs: 5%

SA AL Systems

- ESP: 82%
- NF: 15%
- SRP: 1%
- GL: 1%
- PCP: 1%
2. Challenges

- Heterogeneous Reservoirs
- Different drive mechanisms
- Several Artificial Lift systems
- Reservoir accessibility (Few Y-Tool)
3. Process and Workflow Enablers

- Workflows to Recover More Hydrocarbons
  - PVT properties Tool®
  - Opportunity Maps®
  - Patterns/segments review workflow®
  - Injection Allowable Tool®
  - Structured integrated proactive production optimization workflow®
3.1. PVT Properties Tool

Applications:
- ALS Design for production increase
- Wellbore modeling

This workflow is designed to calculate the oil properties in any place of the reservoir taking into consideration areal and vertical variations based on trends.
3.2. Pressure Opportunity Map

**Applications:**
- Properly manage reservoir decisions
- Identify candidates to increase production / injection

This is a combination of updated reservoir pressure and fluids' properties to provide a fast way to identify areas of opportunity to increase/decrease injection or production based on the development strategy.

**Opportunity Map (Delta P(psia)) = Reservoir Pressure (psia) – Saturation Pressure (psia)**

- Review SBHP/RFT’s
- Review PIP
- Updated pressure maps by layer

- Review all PVTs
- Build maps for each property

- Difference of Res Pressure - Sat Pressure
3.3. Waterflooding Segments Review

Applying Best Practices for Reservoir Management

- Improve the sweep efficiency
- Increase the recovery factor
- Maximize production

<table>
<thead>
<tr>
<th>Well</th>
<th>Recommendations</th>
<th>Data Surveillance Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA-0477</td>
<td>Monitoring (Important)</td>
<td>PGORt</td>
</tr>
<tr>
<td></td>
<td>Stimulate UB-1 and UB-2</td>
<td>-</td>
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<tr>
<td>SA-0552H</td>
<td>Stimulate UB-1 (Fracturation)</td>
<td>-</td>
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<tr>
<td>SA-0084</td>
<td>Add new perforation in UB-1 and UB-4</td>
<td>PNC</td>
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<tr>
<td>SA-0035</td>
<td>Monitoring (Important)</td>
<td>PGOrt</td>
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<tr>
<td></td>
<td>Add perforation in UB-1 (4 to 8 feet)</td>
<td>PNC</td>
</tr>
<tr>
<td></td>
<td>ESP optimization</td>
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</tr>
<tr>
<td>SA-0092</td>
<td>Monitoring (Important)</td>
<td>PGOrt</td>
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<tr>
<td></td>
<td>ESP optimization (up-size)</td>
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<tr>
<td>SA-0088</td>
<td>Keep monitor the well</td>
<td>PLT</td>
</tr>
<tr>
<td>SA-0532H</td>
<td>Keep monitor the well</td>
<td>PGOR</td>
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<td>SA-0119</td>
<td>ESP optimization (increase Hz)</td>
<td>PLT and/or PNC</td>
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<td>SA-0459</td>
<td>ESP optimization (BU, Hz, up-size)</td>
<td>PNC and well integrity</td>
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<td>SA-0090</td>
<td>ZT from MA to UB</td>
<td>PLT</td>
</tr>
<tr>
<td>SA-0124</td>
<td>WFR: Need injection in UB-1 and UB-2</td>
<td>PNL</td>
</tr>
</tbody>
</table>

This integrated analytical workflow includes several tools like analysis of production and injection trends, diagnostic plots mostly in OFM to assess good vs. bad water, Hall plots, reservoir pressure data, tracer data, salinity changes, and PIP trends. Geological analysis (cross-section, well correlation, sand thickness map) for each layer is integrated in each pattern/segment review to support connectivity (or lack of).
3.4. Injection Allowable Tool

Instantaneous and cumulative VRR are calculated and compared with overall exploitation strategy.
Structured and Integrated process to identify production enhancement opportunities in Pro-active approach:

- Increase Oil Production
- Reduce Water Production
- Improve Recovery factor
criteria:

- high pr-pb areas,
- increasing intake pressure and
- water cut <70 %

oil gain opportunity

pattern review performance

pattern/segment reviews

production optimization

opportunities map (pr-pb)

pattern model @ sand face condition, pwf

vsd analysis

upsizing (bigger size)

bean up and/or vsd
Conclusions and Way Forward

Conclusions

▪ Workflows have played a key role:
  - Achieve Production goals
  - Reservoir Management Best Practices
  - Multidisciplinary integration

Way Forward

▪ Standardization across the reservoirs and fields
▪ Automation into OFM, Petrel, PetrelRE
Acknowledgements / Thank You / Questions

- Authors would like to thank the management of Kuwait Oil Company and Schlumberger for their permission to share these workflows as Best Practices.

- Thanks to Sabriyah Team & Special thanks to Mr. Bader Al-Munaifi (NK MFD), Moudi Al-Ajami (NK RS TL) and Hom Chetri, for their continuous support to embed such integrated workflows as best practices in KOC.