MPP on the sea bed, a Technical but also Operational challenge to undertake

Brown Field Application on TOTAL operated Block 17, offshore Angola

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GirRI: a Brownfield project offshore Angola

- ANGOLA - Block 17
- 210 km NW offshore Luanda
- 1,250 m to 1,400 m water depth

Sonangol

GirRI project location

GIRASSOL FPSO
1st Oil: Dec. 2001

DALIA FPSO
1st Oil: Dec. 2006
GirRI: a bold multiphase pumping challenge

- High Boost MPP
- Integrated Power Management Systems

2 World Firsts

MPP subsea module P80
MPP umbilical U80 (18km)
MPP Topside Module
IPC transformer

Girassol FPSO
Dalia FPSO
MPP umbilical U70 (2.5km)
MPP P70 subsea module
Integrated Power Cable (13km)
A Technical Challenge...

- Need for “one pump fits all branches”, wide range of operating points

<table>
<thead>
<tr>
<th></th>
<th>Flowrate (Am³/h)</th>
<th>GVF (% Avol)</th>
<th>ΔP (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating range needed</td>
<td>200 - 550</td>
<td>10 - 60</td>
<td>15 - 105</td>
</tr>
<tr>
<td>Final characteristics</td>
<td>100 - 750</td>
<td>0 - 100</td>
<td>5 - 130</td>
</tr>
</tbody>
</table>

- High ΔP demand: 130 bar

- High shaft power requirement: 2.5 MW per MPP unit.

- World first MPP High boost application (ΔP record with 88.9 bar@ 25%GVF field proven in 05/2016 on P80L MPP).

First main technical challenge was to use a brand new technology from R&D.
Risk mitigation by 1) creating a robust MPP system

- Power and speed margins.
- Increased robustness of the pump.
- Increased robustness of the pumping station.
Risks mitigation by 2) Going through extensive FAT & SIT programs

System Integration Test

Slug Tests
...But also an Operational challenge

- MPP impacts both upstream and downstream flow regimes.

- Operators have a very good experience with their wells. However the MPP modifies the dynamic of the whole multiphase production system.

- Trade off must be found between pushing the MPP speed, choking the wells, rerouting the wells, producing with a higher suction pressure to get a more stable and at longer term a better production.

Start-up and operation of such powerful MPP equipment change many of Operators practices and ways of thinking.
Key difference between a typical Pump and a MPP

With a MPP, the operating limits are function of the GVF and fluid densities ➔ Operating envelope is changing in real-time.
Same MPP on 2 very different configurations:
Very different Multiphase Flow Dynamic systems

Manifold M701 - 4 OP
Depth = 1390m

Manifold M702 - 2 OP
Depth = 1400m

Manifold M703 - 3 OP
Depth = 1360m

Manifold M801 - 2 OP
Depth = 1360m

Seabed

Girassol FPSO

P70 loop

P80 loop

Seabed
Depth = 1360m

17 km

0.3 km

3 km

7 km

0.2 km

3 km
Multiphase Flow Production System Characteristics

- **Flow at inlet is independent from flow at the outlet of the pump.** System is composed of
  - Upstream: wells & flowline.
  - Downstream: riser & gas lift (process topside can also impact MPP).
    → High inertia and limited control.

- **Wells & flowline**
  - Gas fraction in flowrate can reach ups and downs **very quickly** (0-100%)
    → Slug flow conditions with high variations in flowrate.
  - Wells **very sensitive** to backpressure variations (highest impact of MPP is on P80).

- **Riser & gas lift**
  - **Pump needs to create ΔP to enter operating envelope**:  
    → suction pressure to be quickly reduced after start-up (valid for P70 only).
    → rapid effect of gas lift on discharge P (valid for P70 as P80 is far from wells).
    → Location of P80 reduces slugging, enhances stability but raises impact of start-up on wells  
      (drawdown limit).

*A system approach is mandatory*
Main key parameters to manage a successful start-up

Before start-up

- Ramp-down the wells to reach a minimum stable flow.
  → Higher flowrate would require more $\Delta P$ to enter operating envelope.
- Reducing gas lift allows to have margin to play on $\Delta P$ during critical phases (if operating point too close from mini-flow trip limit).
- Closing riser head choke is efficient to increase $\Delta P$ at riser base but disturbs the system at reopening (very sensitive on P70 branch).
- At restart, MPP is speed controlled to enter into the operating envelope.

During start-up

- Wells are then reopened to gain $\Delta P$ & flow, with draw down control.
- Recycle line is used also to get higher $\Delta P$ and stabilize the system.
- Increase/reduction of gas lift allows to reduce/increase $\Delta P$ (quick effects on P70).
Takeaway Points

- MPP on the sea bed is a **Technical** but also an **Operational** challenge to take up.
- Two aspects of the equipment must be equally treated: 1) to Integrate the Equipment, 2) to Operate it.
- Operating successfully a production line with a MPP requires major changes in Operating procedures.
- During the start-up phase, the teams faced more complex flow assurance challenges than anticipated by all studies undertaken and by the Operators training system scenarios.
- Close cooperation between project, commissioning, start-up & operations teams allowed various successful optimizations to maximize MPPs availability and efficiency in restarts.

**Key lesson learnt:**

* A successful transition to a production phase with continuous MPP boosting requires strong collaboration between all teams, Technical knowledge and a whole Subsea System approach.*
Thank you for your attention!
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