Production Optimization – An Industry Perspective

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Agenda

- Decision Making Process
- Motivation
- Expected Benefits
- Adopted Strategy
- BR-SiOP (Production Optimization System)
- Quantifying Benefits
- Main Challenges
- Conclusions
Decision Making Process

- **Data and Simulator:**
  - Better understanding of the process;
  - Identify opportunities;
  - Model the process;

- **Experience:**
  - Knowledge or skills that the engineer gained over time working in the asset;

- **Decision Support Tools:**
  - Search for an optimal operating point;
  - Evaluate a huge number of alternatives when operating under severe process constraints;
  - Enhance process understanding.
Mathematical Optimization - Structure

**Objective:**
- Maximize Oil Production;
- Maximize NPV (Net Present Value);
- Minimize Operational Cost.

**Decision Variables:**
- Production Choke Opening;
- Gas Lift Flow rate;
- Well Routing;
- Water/Gas Injection Flow rate.

**Equality and Inequality Constraints:**
- Water Handling Capacity;
- Liquid Handling Capacity;
- Compression Capacity;
- Amount of Gas Available for Gas Lift;
- Pressure Constraints.

Single or Multi-Objective?

Degrees of Freedom!

Feasible Region!
The characteristics of the wells are changing over time, which implies in a new optimal operating point.
Motivation

- The availability of critical process equipments is changing over time, which also implies in a new optimal operating point.

Graph showing gas flowrate over time, with dates 30/6/2012 to 15/7/2012, and a note about an unexpected shutdown of a compressor on 30/6/2012.
Expected Benefits

✓ Increases production (1 – 3%);

✓ Reduces operational cost;

✓ Fast response to abnormal situations;

✓ Reduces time of the decision making process;

✓ Increases robustness and reliability of the decision making process;

✓ Increases interaction among disciplines.
Adopted Strategy

Production Optimization Loop:

- Optimize
- New Production Test Data
- Simulator
- Valid Models
- Tables
- OPTIMIZER
- Recommendations
- Actions
- Decisions
- Validate recommendation!
- Update Models!
- Run model automatically covering the entire operational envelope

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Decoupled Strategy:

The engineers can use different simulators with the same optimizer.
Adopted Strategy

**Characteristics of the scenario:** Offshore platforms with satellite oil wells.

**Objective:** Maximize Oil Production;

**Decision Variables:**
- Gas Lift Flow rate;
- Pressure upstream choke;
- Gas Flaring;
- Status of the wells (Opened or Closed);
- Well routing (subsea manifold).

**Constraints:**
- Compression Capacity;
- Liquid Handling Capacity;
- Water Treatment Capacity;
- Limit allowed to the gas flaring;
- Gas lift flow rate and wellhead pressure lower and upper bound per well.

**MINLP**

Piecewise Linearization (SOS2)

**MILP**

(Gunnerud, V. and Foss, B., 2009)
Adopted Strategy

Web User Interface

Production Engineers

Asset A

Asset B

Asset C

Petrobras Network

Benefits:

✓ Improved optimization performance with parallel computing;

✓ Easier to maintain and continuously improve the system;

✓ Optimized number of solver licenses.

Computer Cluster located at Cenpes

72 servers HP Dual Xeon quad 3.0 GHz with Microsoft Windows Server 2003 x64 SP 2.

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BR-SiOP – Production Optimization System

- Web Graphical Interface:
BR-SiOP – Production Optimization System

Web Graphical Interface:
BR-SiOP – Production Optimization System

- **Graphs available per well:**
  - Oil Flow Rate versus Gas Lift
  - Downhole Pressure versus Gas Lift
BR-SiOP – Production Optimization System

- Sensitivity Analysis – Process Constraints:

![Image of production optimization system interface]
BR-SiOP – Production Optimization System

- Sensitivity Analysis – Process Constraints:

![Image of the BR-SiOP interface showing sensitivity analysis results for process constraints.](image_url)
BR-SiOP – Production Optimization System

- Sensitivity Analysis – Process Constraints:
BR-SiOP is an useful tool to assist engineers in the quantification of losses due to unavailability of critical process equipments.
Quantifying Benefits

Case Study 1 – FPSO with 13 wells:

Comparison based in production historical data – normal operating scenario.

Gains ranging from 0.37 to 1.55%

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Quantifying Benefits

Case Study 1 – FPSO with 13 wells:

Comparison based in production historical data – normal operating scenario.

Gains ranging from 0.24 to 1%

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Quantifying Benefits

Case Study 1 – FPSO with 13 wells:

Comparison based in production historical data – normal operating scenario.

Total Gas Lift [Sm³/d]

Scenarios - Days

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Quantifying Benefits

Case Study 2 – FPSO with 13 wells:

Comparison based in a real scenario – limited compression capacity.

Action of the Platform Operators

Action Based in the Recommendation of the Optimizer
Quantifying Benefits

- Case Study 2 – FPSO with 13 wells:

Comparison based in a real scenario – limited compression capacity.

Total Gas Lift [Sm³/d]

Time (sample number)

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Quantifying Benefits

Case Study 2 – FPSO with 13 wells:

Comparison based in a real scenario – limited compression capacity.

Total Oil Produced [m³/d]

Production Increased 1.18%
The production optimization strategy presented assumes that the process is “stable”. It means that dynamic instabilities like severe slugging must be addressed by the regulatory and advanced control layers.
Main Challenges

- Uncertainty Propagation:
  - Watercut
  - GOR
  - Reservoir Pressure
  - Productivity Index

Uncertainty Propagation Diagram:

- Simulator (Model)
- Parameters
- Optimizer
- Variables

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Main Challenges

- **Uncertainty Propagation:**

Due to the uncertainty the optimum will be a region instead of a point.

Opportunity for the use of Robust Optimization Techniques!

This region can be explored by the field operator or by the well control system (closed loop).

Input Parameters

Gas Lift

Produced Oil

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Objective: Maximize Oil and Gas Production;

Decision Variables:
✓ Gas lift flow rate;
✓ Pressure upstream choke;
✓ Well routing in the subsea manifold;
✓ Status of the wells (opened or closed).
✓ MEG flowrate;

Constraints:
✓ Gas, oil and water treatment capacities;
✓ Pressure in the pipeline network;
✓ CO₂ content in the gas;
✓ UTGCA gas and condensate treatment capacities.
Main Challenges

❖ Human Aspects:

✓ Proactive x Reactive approach (continuously search for the opportunities for improvements);

✓ Training (good understanding of what is inside of the optimizer);

✓ Good integration between onshore and offshore team (operator is part of the optimization loop);

Without these items the gain can be 0%.
Main Challenges

- **Human Aspects:** Training and knowledge dissemination.

**Production Optimization:**
- Training courses;
- Workshops;
- Conferences.

- Training Course – Rio, January 2012.
Conclusion

✓ A decision support system to assist engineers and operators in the production optimization process was developed and made available for three different assets from Campos Basin (P-54, P-50 and P-53).

✓ The preliminary results obtained with the use of the decision support system are promising.

✓ Two case studies with a quantification of the benefits of the decision support tool for production optimization were presented.

✓ One of these case studies was a real example where the use of the decision support system resulted in an increase of about 1.18% in the total oil flow rate produced by the platform.

✓ The main technological and human challenges related with production optimization were presented.
THANK YOU!

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