Digitalization of Production Systems

A Catalyst for Early Detection and Mitigation of Future Risks

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Introduction

World and Industry facing a VUCA environment on a daily basis

VUCA

VOLATILITY  Subject to fluctuations and change

UNCERTAINTY  Due to change, instability and unavailable information

COMPLEXITY  Overwhelming in scope and variables

AMBIGUITY  Multiple cause-and-effect factors
How to live under a VUCA environment?
Continuous evolution and change the paradigm of simulation

**HOW?**
- Online monitoring
- Predictive Analysis
- AI applications
- Continuous follow up

**NEEDS**
- Increase of Computational Power
- Continuous Software Development
Understanding the Uncertainty in Flow Assurance

Complex scenarios require digitalization of the production systems

- Complex multiphase flow problem, only possible to deal with adequate software;
- Frequent necessity to run sensitivity analysis in Flow Assurance models;
- Preparation and post processing of cases and sensitivities is very time consuming;
- Difficult to identify robust/firm deterministic value for the required inputs - specially for projects in early stages of development;

Complex scenarios with several uncertainties in key parameters
Automation of workflows
Python toolkit as a robust solution for scripting and implement personalized tools

Create an user-friendly in-house tool that allows a time efficient setup of multiple cases on PIPESIM Flow Assurance Models;

Python toolkit as a solution to automate procedures and empower PIPESIM.
User interface made with Excel
Digitalization of Production Systems

Python toolkit unlocking development of tools

Better understanding of uncertainty and continuous monitor of well productivity achieved by two tools developed in-house using Python Toolkit from Schlumberger

OpEn Tool

Operational Envelope Stochastic Analysis
Pre-development and Development

Sensitivity tool with implementation of Monte Carlo method for stochastic analysis of operational envelopes

ProMo Tool

Well Productivity Monitoring Tool
Production

Well PI continuous monitoring with all the uncertainty associated to reservoir properties/behaviour with time
OpEn Tool – Stochastic Analysis
Monte Carlo method implemented to better understand and assess uncertainties

HOW TO DEAL WITH IT?

- Extensive sensitivity analysis on multiple parameters;
- Imposing probabilistic distributions to each parameter rather than deterministic values;
- Associate probability of occurrence of certain outcome scenarios.

Monte Carlo Simulation for Flow Assurance
OpEn Tool Workflow
User friendly generation of stochastic case matrix with customizable set of primary parameters

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### Variable Description

<table>
<thead>
<tr>
<th>Variable Description</th>
<th>Object Type</th>
<th>Object Name</th>
<th>Variable</th>
<th>Original Value</th>
<th>Units</th>
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<tr>
<td>Completions</td>
<td>W1:W1,cmp1</td>
<td>Reservoir Static Pressure</td>
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<td>bara</td>
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<td></td>
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<tr>
<td>Completions</td>
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<td>sm3/sm3</td>
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<tr>
<td>Completions</td>
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<td>%</td>
<td></td>
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</table>

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**Step 1 - Import**

- Change: Uniform
- Distribution: 400
- Param1: 100
- Param2:
- Param3:

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**Step 2 - Define how variables change**

- Change: Histogram
- Distribution: Permeabilities
- Param1: 500
- Param2: 50
- Param3:

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**Step 3 - Run Script**

- Change: Normal
- Distribution: 500
- Param1: 50
- Param2:

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**Step 4 - Analyze Results**

- Change: Uniform
- Distribution: 400
- Param1: 100
- Param2:

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**Digitalization of Production Systems**

8 | Galp
Case study: WI system deliverability capturing reservoir uncertainty

Stochastic results available to have better understand most likely operational envelope

**Objective:**
- Most likely water injection volumes while coping with uncertainty of reservoir behavior / Properties

**Conditions and Arrangement**
- 4 Wells in 14 km Daisy Chain
- High Pressure reservoir
- Development stage

**Sensitivity:**
- Reservoir permeability
- Reservoir Depletion

8000 Cases
14.5 h
ProMo tool for PI monitoring
Continuous monitoring of well PI for early detection of potential well impairment

\[ PI = \frac{Q}{P_{res} - P_{BHFP}} \]

**Q**
For satellite wells, flowrate is usually known with good precision.

**P_{BHFP}**
Flowing bottom hole pressure usually known through usage of PDG on the well.

**P_{res}**
Reservoir pressure only possible to estimate after long pressure build-up periods or with reservoir model.

**PI**
Original PI possible to be estimated based on reservoir properties and early production.
Requires good understanding on key reservoir parameters (permeability, fluid properties, static pressure, etc.)

Available on a daily basis

Uncertainty on value throughout field life
ProMo tool workflow
Simple methodology used to estimate Reservoir Pressure

User Environment
Create well model from PDG upwards

Field data matching

Run Script

Analyze Results

Ran in Background
Run for each daily production report:
1. Impose reported flow rate and PDG value
2. Run to calculate Inlet Pressure / Reservoir pressure
3. Register Inlet Pressure / Reservoir pressure
Case study: UDW well with no impairment

ProMo confirmed no impairment on the well and pressure support after start of water injection

- Satellite Well
- Early life of well and field
- Little influence from nearby wells
- Change of decline rate explained by start of water injection
- Period without information due to lack of PDG data
- Pressure profile that can be compared with other reservoir models

Start of Water Injection

Reservoir Pressure in Well X

Month 0 Month 4 Month 8 Month 12 Month 16
UDW well with formation damage due to scaling

Detection of productivity impairment allowed partners to push for an intervention.

- Engagement with Operator to push for Well Intervention
- Decline rate decrease after entrance of Water Injector (WI)
- Decline rate acceleration after entrance of new Producer (Prod)
- PI clearly recovered after well acidification and scale squeeze
- Excessive decline rate with no justification from the reservoir point of view: Possible well impairment

Reservoir Pressure in Well Y

Analysis performed together with scale assessment and reservoir expected behavior
Conclusions

Python Toolkit for PIPESIM proved to be a catalyst for developing tools that improve flexibility and agility.

- Enabler of Stochastic Flow Assurance analysis;
- Expander of PIPESIM native sensitivity capabilities;
- Better understanding on impacts from uncertainties associated to the project;
- User friendly and powerful tool to monitor well productivity index on a continuous basis;
- Additional tool for follow up of well behavior throughout field life.

We are committed to continue to develop knowledge and application of state of the art tools, to generate value to the world class partnerships where we participate.

The future is open.