Probabilistic Algorithm-driven Well Trajectory Optimisation Study for a Green Field Project in the NCS

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Optimal well location & trajectory definition for injector-producer is critical

Multiple impacting parameters → complex optimisation problem

Typical approach: simulation of several deterministic scenarios

Objective approach: simultaneous multi-parameter optimisation (standoff, orientation, etc)

+ eventually add uncertainties (structural models, NTG, permeability, etc)

What’s the optimal location and trajectory for the wells?

How to make well location optimisation process more efficient?

Solution = Python trajectory discretisation + automated workflow + optimisation algorithm

6.5% increase on field production from optimised well trajectories
WELL TRAJECTORY OPTIMIZATION

MODEL DESCRIPTION

- Black oil model
- 2 MM cells $\rightarrow$ 230K active cells (55mx55mx4m)
- Equilibrium initialisation + endpoint scaling
- Predefined locations for 2 producers (horizontal) + 1 injector (deviated)
- Green field project + 16 years forecast prediction
- Simulation time $\approx$ 45 min
WELL TRAJECTORY OPTIMIZATION
MODELLING THE WELL TRAJECTORIES

- Focus on trajectory *intersecting* the reservoir
- Discretisation of well trajectory into segments (sections) using Python script:
  - 1 segment representing wellhead to entry point
  - 1 segment connects entry point & horizontal section
  - 2 segments representing horizontal section
- Trajectory constrained by grid top/base
- Horizontal section lays on WOC stand-off
WELL TRAJECTORY OPTIMIZATION
MODELLING THE WELL TRAJECTORIES

Which parameters to optimise for each well?

- Wellhead location \((X, Y)\) – fixed for this model
- Well segments length \((A, B, C)\)
- Well segments azimuth \((\alpha, \beta, \gamma)\)
- WOC stand-off

- Python trajectories replace original trajectories during optimisation
- Input trajectories approximated by trial & error for base model
- Production mismatch with original model/trajectories < 1%
Particle Swarm Optimization (PSO)

- Based on avian flock behaviour
- Swarm of particles \((\text{models})\) affected by behaviour-like parameters
- Global and Local best positions updated for each iteration
- Inspired by evolutionary processes

Differential Evolution

- Best individuals \((\text{models})\) selected from each population (iteration) to create the next one
- Local DE option looks for local optimum – fast convergence
- Global DE option looks for global optimum – more iterations needed
WELL TRAJECTORY OPTIMIZATION

OPTIMIZATION RESULTS

- 3 experiments x 600 runs each
- Local DE & PSO → convergence at 200 variants
- Global DE → convergence at 400 variants
- ALL three experiments lead to improvement of base case
  - Local DE ~ 3 MMboe (6.5%) increase in oil production
  - PSO ~ 1.8 MMboe (4%) increase in oil production
  - Global DE ~ 1.5 MMboe (3%) increase in oil production
Parameter search-space fully explored

PSO converges at different optimum value compared to DE

Optimisation confirms original stand-off for W1 but 10m reduction suggested for W2
- Field production acceleration observed for all 3 solutions
- Field production increase observed for all 3 solutions
- Recovery increase for both production wells
- Slight reduction on water injection also
WELL TRAJECTORY OPTIMIZATION

OPTIMIZED VS. ORIGINAL WELL TRAJECTORY

- Original trajectories vs optimized for 1 possible solution
- Optimization workflow $\rightarrow$ several *different potential solutions* = trajectories
- QC is recommended to check optimization variables converge to reasonable values
- Several trajectories to be validated with drilling team
WELL TRAJECTORY OPTIMIZATION

LESSONS LEARNT AND CONCLUSIONS

• The routine approach for new well trajectories requires testing alternative trajectories in discrete scenarios → time and money consuming

• The automated approach optimises well trajectories relying on a stochastic process

• 100’s of simulations exploring multiple scenarios with minimal user intervention

• Multiple variables can be optimised simultaneously – uncertainties can be added for forecasting stage

• The workflow can be easily transferred to other projects

• Using the optimization process well trajectories were improved and cumulative oil production by approximately 6.5%

• The QC did not find evidence of unrealistic trajectories → a careful selection of the parameters’ ranges + flexible trajectory definition workflow can produce consistent results

• Optimization algorithms + automated workflows + parallel calculations is a relevant tool for engineers and geoscientists when looking for more efficient and exhaustive techniques to define well trajectories.

• RE-Geoscience-DR team expertise is always required to select realistic variable ranges and a realistic well trajectory!
Thank you!

Questions?