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Reference documents

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7 Sentences were found in a text with the title: „***Robust Optimization of Water-Flooding in Oil Reservoirs Using Risk Management Tools***", located at:
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6 Sentences were found in a text with the title: „***Application of multi-criterion robust optimization in ...38***", located at:
https://www.sciencedirect.com/science/article/pii/S0920410513001757

5 Sentences were found in a text with the title: „***Handling risk of uncertainty in model-based production ...5***", located at:
https://www.sciencedirect.com/science/article/pii/S2405896315009064
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https://www.narcis.nl/publication/RecordID/oai:pure.tue.nl:publications/dfc1dd85-69da-4d76-bce7-20cdd1bf3fb7

5 Sentences were found in a text with the title: „***Nonlinear Model Predictive Control 0.3 cm for Oil Reservoirs Management***", located at:
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.716.1892&rep=rep1&type=pdf
http://www2.imm.dtu.dk/~jbjo/PhD_Thesis_2013_AndreaCapolei.pdf

5 Sentences were found in a text with the title: „***Risk management in oil reservoir water-flooding under ...***", located at:
https://ieeexplore.ieee.org/document/7403410/
https://www.researchgate.net/publication/304410854_Risk_management_in_oil_reservoir_water-flooding_under_economic_uncertainty

5 Sentences were found in a text with the title: „***OilField 2015 Book of Abstracts***", located at:
http://folk.ntnu.no/skoge/prost/proceedings/offshore-control-2015/OOGP15_BookOfAbstracts.rtf

4 Sentences were found in a text with the title: „***Handling risk of uncertainty in model-based production optimization: a robust hierarchical approach***", located at:
https://research.tue.nl/en/publications/handling-risk-of-uncertainty-in-model-based-production-optimizati
https://www.researchgate.net/publication/282316393_Handling_risk_of_uncertainty_in_model-based_production_optimization_a_robust_hierarchical_approach
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4 Sentences were found in a text with the title: „***Reservoir development optimization under uncertainty for ...3***", located at:
https://researchportal.hw.ac.uk/en/publications/reservoir-development-optimization-under-uncertainty-for-infill-w
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4 Sentences were found in a text with the title: „***Reducing the effect of uncertainty in model-based economic optimization for oil recovery***", located at:
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4 Sentences were found in a text with the title: „***Model and Economic Uncertainties in Balancing Short-Term ...***", located at:
https://www.researchgate.net/publication/282752938_Model_and_Economic_Uncertainties_in_Balancing_Short-Term_and_Long-Term_Objectives_in_Water-Flooding_Optimization

4 Sentences were found in a text with the title: „***Time-explicit methods for joint economical and geological ...***", located at:
https://core.ac.uk/download/pdf/43257834.pdf
https://orbit.dtu.dk/en/publications/time-explicit-methods-for-joint-economical-and-geological-risk-mi

4 Sentences were found in a text with the title: „***Dynamic risk management in petroleum project investment based on a variable precision rough set model.pdf***", located at:
https://www.researchgate.net/profile/Gang_Xie10/publication/222145162_Dynamic_risk_management_in_petroleum_project_investment_based_on_a_variable_precision_

3 Sentences were found in a text with the title: „***A Least Squares Method for Ensemble-Based Multi-Objective Oil Production Optimization***", located at:
http://folk.ntnu.no/skoge/prost/proceedings/ifac-oogp18/OOGP18/0005.pdf

3 Sentences were found in a text with the title: „***M.Mohsin Siraj - Google Scholar Citations***", located at:
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3 Sentences were found in a text with the title: „***Universidade Estadual de Campinas***", located at:
https://www.fem.unicamp.br/files/CEP - Publicacoes/Denis_Jos_Schiozer(2).pdf

3 Sentences were found in a text with the title: „***Optimizing smart well controls under geologic uncertainty ...29***", located at:
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https://www.sciencedirect.com/science/article/pii/S0920410510001099

3 Sentences were found in a text with the title: „***Oil production uncertainty assessment by predicting reservoir production curves and confidence intervals from arbitrary proxy responses.***", located at:
https://hal.univ-lorraine.fr/hal-02136465/file/JPSE_paper_AuthorVersion.pdf

3 Sentences were found in a text with the title: „***Robust optimization – A comprehensive survey - ScienceDirect1559***", located at:
https://www.sciencedirect.com/science/article/pii/S0045782507001259

3 Sentences were found in a text with the title: „***Pareto-based robust optimization of water-flooding using ...10***", located at:
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https://www.sciencedirect.com/science/article/pii/S0920410515001874

3 Sentences were found in a text with the title: „***SubmittedManuscript.pdf***", located at:
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3 Sentences were found in a text with the title: „***A Least Squares Method for Ensemble-based Multi-objective Oil Production Optimization **This project is financially supported by the Danish Hydrocarbon Research and Technology Centre.***", located at:
https://orbit.dtu.dk/files/151671238/1_s2.0_S2405896318306773_main.pdf

3 Sentences were found in a text with the title: „***Time-explicit methods for joint economical and geological ...3***", located at:
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https://www.sciencedirect.com/science/article/abs/pii/S0920410516301243

3 Sentences were found in a text with the title: „***"John Bagterp Jørgensen - Publications - DTU Orbit (270415).ris";***", located at:
http://orbit.dtu.dk/en/persons/john-bagterp-joergensen(d2bc6de4-a5c6-43f7-8712-606bd02a88e9)/publications.ris?page=14&nofollow=true

2 Sentences were found in a text with the title: „***A multiobjective Markov chain Monte Carlo approach for ...2***", located at:
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2 Sentences were found in a text with the title: „***Robust optimization of water-flooding in oil reservoirs ...8***", located at:
https://research.tue.nl/en/publications/robust-optimization-of-water-flooding-in-oil-reservoirs-using-ris
https://www.sciencedirect.com/science/article/pii/S2405896316304360

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2 Sentences were found in a text with the title: „***Utilisation de méta-modèles multi-fidélité pour l'optimisation de la production des réservoirs***", located at:
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2 Sentences were found in a text with the title: „***Optimizing smart well controls under geologic uncertainty ...***", located at:
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2 Sentences were found in a text with the title: „***1801.00684***", located at:
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2 Sentences were found in a text with the title: „***جستجو در مقالات دانشگاهی و کتب استادان دانشگاه فردوسی مشهد***", located at:
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2 Sentences were found in a text with the title: „***Serval - Local and global error models to improve ...5***", located at:
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2 Sentences were found in a text with the title: „***Robust Optimization of Cyclic CO2 flooding through the Gas ...4***", located at:
https://www.sciencedirect.com/science/article/abs/pii/S0920410518302304
https://pennstate.pure.elsevier.com/en/publications/robust-optimization-of-cyclic-co2-flooding-through-the-gas-assist

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2 Sentences were found in a text with the title: „***An Adaptive Robust Optimization Scheme for Water-Flooding Optimization in Oil Reservoirs Using Residual Analysis***", located at:
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2 Sentences were found in a text with the title: „***Dynamic risk management in petroleum project investment ...***", located at:
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https://www.sciencedirect.com/science/article/pii/S0040162510000272

2 Sentences were found in a text with the title: „***Siraj&etal_IFAC_OOGP2018_subm.pdf***", located at:
http://www.publications.pvandenhof.nl/Paperfiles/Siraj&etal_IFAC_OOGP2018_subm.pdf

2 Sentences were found in a text with the title: „***An adaptive robust optimization scheme for water-flooding optimization in oil reservoirs using residual analysis **The authors acknowledge financial support from the Recovery Factory program sponsored by Shell Global Solutions International.***", located at:
http://pure.tudelft.nl/ws/files/36833323/1_s2.0_S2405896317322334_main.pdf

2 Sentences were found in a text with the title: „***Philippe RENARD | PhD - ResearchGate***", located at:
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2 Sentences were found in a text with the title: „***Capolei2013_WaterfloodingOptimization.pdf***", located at:
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2 Sentences were found in a text with the title: „***(PDF) A mean–variance objective for robust production ...***", located at:
https://www.researchgate.net/publication/270344802_A_mean-variance_objective_for_robust_production_optimization_in_uncertain_geological_scenarios

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Subsequent the examined text extract:

Short Survey of Optimization Methods in Petroleum Reservoir Management

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Abstract

The recent increase in oil demand worldwide combined with the decreasing number of new discoveries has underscored the need to efficiently produce existing oil fields. The maturity of most of the existing large fields requires prudent reservoir management and development strategies to maximize recovery. On the other hand, various sources of uncertainties during the petroleum field development such as geological uncertainties, operational uncertainties, economic uncertainties have negative impact on sound reservoir management, therefore handling of uncertainty is vital in production optimization.

There is a wide range of studies about Petroleum reservoir management under uncertainty data in the literature.

We give a short survey of previous working about the optimization methods and uncertainty management in reservoir field development.

Keywords

Reservoir management, optimization methods, uncertainty management.

Introduction

There are multiple sources of uncertainty in the petroleum field development that make an incorrect prediction of the future performance of the reservoir.

In general, uncertainties in reservoir management data are divided into four groups.

UNCERTAINTY IN ENGINEERING DATA (Schulze-Riegert and Ghedan 2007).
Uncertainty in geophysical data

Seismic statistics, which are used for building reservoir structure and shape, are afflicted by uncertainties. Those uncertainties correspond to data gathering, data processing and statistics interpretation.

The cause of these uncertainties is:
Data gathering error
Different interpretations
Depth data converting error
Error in preliminary interpretation
Error in wave length map corresponding to reservoir crest
Uncertainty in geological data

Possibly the most uncertainty in reservoir modeling are the one from geological data. In geological data, uncertainties are because of sedimentation, nature of rock (lithology), extension region of rock, and rock properties. These result in the subsequent uncertainties:
Uncertainty in gross volume of reservoir
Uncertainty in direction and size of sedimentation
Uncertainty in different rock type extension

Uncertainty in porosity
Uncertainty in net-to-gross ratio
Uncertainty in fluid contacts

These uncertainties have a few consequences on evaluation of hydrocarbon in-place and dynamics of fluid through the reservoir.

Uncertainty in dynamic data

Uncertainties of all parameters that have an effect on fluid flow through a reservoir (inclusive of absolute permeability, vertical to horizontal permeability, relative permeability, fault transmissibility, injectivity, productiveness index, pores and skin, capillary stress, aquifer houses) are considered in this phase. These uncertainties affect both the reserve estimation and production profile.

Uncertainty in PVT data

PVT data could be considered the least unsure data. Uncertainty in PVT data influences the ability of processing units, hydrocarbon shipping and advertising, marketing. A number of the uncertainties in this segment are:
Uncertainty in fluid samples: sampled fluid can be unrepresentative of the reservoir fluid. This would have an effect on decided on better oil efficiency (EOR) eventualities.
Uncertainty in fluid composition
Uncertainty in PVT properties measurement.
Uncertainty in interfacial tension data.

Uncertainty in field performance data

In addition to the above uncertainties, field performance data may suffer uncertainties:
Oil production costs are generally measured systematically and precisely however Water Oil Ratio (WOR) and Gas Oil Ratio (GOR) measurements are accomplished sometimes.
Production rate fluctuations are normally smoothed out as they are able to arise at brief durations.
Gas rate are not measured correctly, particularly when a part of it is flared.
Injection data are less correct than production data due to the errors existing in measurement phase, fluid losses into different intervals due to leaks in the casing or flow behind the pipe.
Pressures measured at some stage in flow assessments are usually less dependable than the ones obtained at some stage in shut in.

UNCERTAINTY IN ECONOMICAL DATA

Real-life applications of production optimization face challenges of risks related to unpredictable fluctuations in oil prices. Conventional production optimization methods focus on long-term net present value (NPV).

A major drawback of such methods is that the time-dependent and exceedingly growing uncertainty of oil prices implies that long-term predictions become highly unreliable. Conventional methods therefore leave the oil production subject to substantial economic risk. (Christiansen, Capolei et al. (2016)), (Christiansen, Hørsholt et al. (2018))

UNCERTAINTY IN POLITICAL DATA

UNCERTAINTY IN ENVIRONMENTAL DATA

Dealing with above uncertainty is an important topic encountered in petroleum field development. Reducing the uncertainty itself, using measurements and reducing the sensitivity to the uncertainty are two different strategies which are not basically conflicting with each other, that are mentioned in research papers.

In this paper, we give the short survey of some optimization methods in petroleum field development under uncertainty data, both reducing the uncertainty and sensitivity to the uncertainty.

we are motivated to discuss and provide an up-to-date survey of the optimization techniques, used to tackle these issues. So, we will shortly review the different sources and kinds of uncertainties in the petroleum field development and provide the review the different optimization sources and kinds of uncertainties that can be encountered when facing design problems.

Methods

Concepts of robustness and robust optimization have been developed independently in different scientific disciplines, mainly in the fields of engineering design.
While the methods of stochastic (linear) programming may be regarded as a first approach to deal with uncertainties treating robustness as a side effect only, the notion of robust optimization gained focus in engineering fields after the publication of Mulvey and Bai (J. Mulvey, R. Vanderbei et al. 1995, D. Bai, T. Carpenter et al. 1997)
Robust design and optimization have even deeper roots in engineering. It is inextricably linked with the name of Taguchi who initiated a highly influential design philosophy and gained increasing interest in the past few years. (Beyer and Sendhoff 2007)

In petroleum filed development, risk management is a key aspect when considering investments in petroleum projects. Geological, economic and technological risks that are associated to Exploration & Production projects, strongly influence the oil recovery. The acquisition of additional information and flexibility are key points to risk mitigation. (Hayashi, Ligero et al. 2010)

The nature of risks and the quantum of risk exposure (RE) are both dynamic, frequently challenging the efficacy and efficiency of the risk management. Hence, there is the need to investigate dynamic risk management in petroleum projects and robust optimization production. (Xie, Yue et al. 2010)

<u>Uncertainties and Robust Optimization</u>

Van Essen et al. (2009) presented Robust Optimization (RO) approach to reduce the impact of geological uncertainties in the petroleum field development phase. They used a set of realizations that reflect the range of possible geological structures honoring the statistics of the geological uncertainties. The associated objective function was NPV in terms of a single objective with pre-defined costs and oil price. They used a classical gradient-based optimization method where the gradients were obtained with an adjoint formulation.

Alhuthali et al. (2010) approach is equalizing arrival time of the waterfront at all producers using multiple geologic realizations. They used two optimization schemes for geologic uncertainty; expected value and standard deviation on stochastic form combined with a risk attitude coefficient.

Their approach was the analytical computation of the gradient and Hessian of the objective function.

Almeida et al. (2010) used a genetic algorithm for obtaining a pro-active control strategy and determining an operation that maximized the single objective net present value (NPV), in intelligent oil fields, under technical and geological uncertainties

Chen and Hoo (2012) compared two different methods, Markov chain Monte Carlo(MCMC) and an ensemble Kalman filter(EnKF), to achieve continuous updates of the uncertain parameters, in managing the amount of water added to a reservoir (water flooding project)

This management is accomplished by employing an optimal model-based control framework that includes uncertain parameter updating and a particular low-order model identified from a first-principles model.

The model parameter updating resulted in increased oil production (9.0% and 8.2% with EnKF and MCMC updating, respectively) and decreased water production in the final cumulative net present value.

Also, it was shown that updating the values of the geologic uncertain parameters (porosity and permeability) is important in optimizing the oil production of the reservoir due to affect the amount of water injected to force the trapped oil out.
Capolei, Suwartadi et al. (2013) consider an open-loop optimization scenario, with no feedback, and a closed-loop optimization scenario in waterflooding optimization under geological uncertainty. They proposed a modified robust optimization strategy (modified RO) with larger returns and less risk to improve the RO strategy. The returns were measured by the expected NPV and the risk was measured by the standard deviation of the NPV.

Yasari, Pishvaie et al. (2013) presented an interesting approach to focus on reducing the sensitivity to the uncertainty when no measurement information was assumed to be available.

For this purpose, the robust optimization methodology was configured to find multiple Pareto-optimal solutions without a priori knowledge of the reservoir dynamic models by using a derivative-free Evolutionary Multi-objective Optimization (EMO) procedure in the form of a revised Non-dominated Sorting Genetic Algorithm (NSGA), called as NSGA-II. Then in 2015 they proposed multi-objective optimization formulation would attempt to find the optimum – yet robust – water injection policies. Two multi-objective, Pareto-based robust optimization scenarios have been investigated to encounter the permeability uncertainties.

The test studies demonstrated the superiority of the proposed methodology to give a robust optimal Pareto-based solution(s) (injection policies) under permeability uncertainties that could be reliable for the original set of realizations.((Yasari and Pishvaie 2015))

Capolei, Suwartadi et al. (2015), demonstrated by open-loop simulations of a two-phase synthetic oil field that the mean–variance criterion is able to mitigate the significant inherent geological uncertainties better than the alternative certainty equivalence and robust optimization strategies that have been suggested for production optimization.
They showed that certainty equivalence optimization and robust optimization are risky strategies, but mean–variance optimization is a powerful tool for risk management and uncertainty mitigation in production optimization.
Siraj, Van den Hof et al. (2015) formulated a multi-objective optimization problem which considers both economic and model uncertainties to mitigate the negative effects i.e., risk of these uncertainties on the production strategy.
They achieved the improved robustness without heavily compromising the primary objective of economic life-cycle performance. Also, they used an ensemble of varying oil price scenarios and geological model realizations to characterize the economic and geological uncertainty space respectively. The primary objective is an average NPV over these ensembles.
As the risk of uncertainty increases with time, the secondary objective of their work was maximize the speed of oil production to mitigate risk. This multi-objective optimization was implemented separately with both forms of uncertainty in a hierarchical or lexicographic way.

Geological uncertainty has a significant impact on the optimal well placement plan and therefore has to be considered in the well placement optimization problem. Rahim and Li (2015) proposed the geological realization reduction framework for well placement under geological uncertainty.

Hanssen and Foss (2015) formulated the production optimization problem as a two-stage stochastic programming problem and the solution was a strategy for operating the wells, instead of a single setpoint obtained from the deterministic problem. As the model-based economic optimization of the water-flooding process in oil reservoirs suffers from high levels of uncertainty, the concepts from the theory of risk are highly relevant. They offered in another work, an asymmetric risk management, i.e., to maximize the lower tail (worst cases) of the economic objective function distribution without heavily compromising the upper tail (best cases). They considered the Worst-case robust optimization and Conditional Value-at-Risk (CVaR) risk measures under geological uncertainty to improve the worst case(s).also a deviation measure, semi-variance was used in geological and economic uncertainty that were characterized by an ensemble of geological model realizations and ensemble of varying oil price scenarios respectively, to maximize the lower tail. (Siraj, Van den Hof et al. 2016, Siraj, Saltik et al. (2018))

Foroud, Seifi et al. (2016) and Siraj, Van den Hof et al. (2017) emphasized on geological model as a main source of uncertainty in petroleum reservoir simulation which can reduce reliability of simulation results in optimization process. They suggested the clustering algorithms like Kernel K-means Method (KKM) to select a representative subset of geological models and reduce the high computational cost during the simulation process.

Some researchers approach is managing uncertainty in field development. They presented the new methodologies based on optimized production strategy and decision-making process to measure and reduce the risk. They are called risk management. For example Santos, Gaspar et al. (2017) considered the robust risk management method in the development of complex petroleum fields by adding flexibility to the production system and creating robust production strategy.

The proposed method is based on performance analysis of a deterministically optimized production strategy over all possible scenarios, refining it to further improve the optimization process and reduce risk. The concept of this method is Multi-Attribute Utility Theory (MAUT) with multiple objectives (technical and economic indicators).

In following work, they proposed the systematic, objective approaches to quantitatively estimate the expected value of flexibility (EVoF). This method is applicable to complex reservoirs in development phase with multiple uncertainties affecting the production strategy selection. Santos, Gaspar et al. (2018)

Silva, dos Santos et al. (2017) proposed a five-stage methodology to estimate the value of flexibility in petroleum production projects under endogenous and exogenous uncertainties. Each stage is split into steps to identify the details of problem modeling and strategy selection.

Estimating the uncertainties on the aquifers response of reservoirs by performing full physics flow simulation on a large ensemble of models implies often prohibitive intractable computational costs and time. To overcome this problem, some approaches consider an approximate solution (flow proxies) for addressing this challenge. (G. Bardy 2014) or cluster the realizations in a multidimensional space based on the flow responses obtained by means of an approximate (computationally cheaper) model. (L. Josset 2013)

Bardy and Biver used both approches and integrated the dynamic behavior of the whole set of models to capture the uncertainties for a larger class of proxies to be considered. (Bardy, Biver et al. 2019)

Olalotiti-Lawal and Datta-Gupta provided a novel approach for subsurface model calibration and uncertainty quantification using Markov chain Monte Carlo (McMC) in which the communication between parallel Markov chains enhances adequate mixing. This method significantly improves the convergence without loss in sampling quality. (Olalotiti-Lawal and Datta-Gupta 2018)

According to geological uncertainty as a significant challenge in petroleum field development, Zanbouri and Salahshoor presented the new robust modeling methodology to identify a set of robust surrogate models with unstructured uncertainty for economic performance prediction of an uncertain oil reservoir under water flooding process. Zanbouri and Salahshoor (2018)
in this new methodology, identified MIMO surrogate model was integrated with a desired nonlinear net present value (NPV) objective function to synthesize a new modified robust surrogate model in a multi-input, single-output (MISO) configuration form and enable direct calculation of economic performance prediction.
Mudhafar developed the robust optimization approach to determine the optimal durations of gas injection, soaking, and oil production under geological uncertainties in heterogeneous reservoirs. Al-Mudhafar, Rao et al. (2018)
The robust optimization workflow under geological uncertainties in his study, presented higher oil recovery and net present value than nominal realization optimization, with providing degree of freedom for the decision-maker to significantly reduce the project risk.

Due to uncertain oil price environment, brownfield redevelopment is an attractive option to manage production decline and optimally placing the infill well to maximize recovery and minimize operational expenditure is an essential strategy. Park, Yang et al. (2017)

Hutahaean and Demyanov introduced a new workflow for robust and reliable well placement optimization under geological uncertainty. In their proposed workflow multi-objective assisted history matching, Bayesian posterior inference, and well placement optimization integrated in multi-objective setting across multiple geological models. The proposed workflow provides robust and reliable optimal decisions in placing the infill well over multiple history match models. (Hutahaean, Demyanov et al. 2019)

Well placement optimization is a major challenging problem in oilfield development and reservoir management because reservoir heterogeneities produce profoundly non-smooth, discontinuities, nonconvex cost functions containing multiple local optimums. Also, large number of reservoir simulations need to be executed.

There are lots of optimizing techniques which evaluate wells location can be classified into two groups of approaches: gradient-based ex, (Jansen 2011) and derivative-free ex, (Bellout, Ciaurri et al. 2012) approaches.

In recent years, the optimization algorithms that have been implemented to improve well placement optimization problem under uncertainty and reduce computationally problem. (Janiga, Czarnota et al. 2019, Islam, Vasant et al. 2020)

Simultaneous Perturbation Stochastic Approximation (SPSA) algorithm, which is a local optimization method is used by Jesmani (Jesmani, Jafarpour et al. 2020) and his colleagues to consider an infill drilling scenario for vertical and horizontal wells placement optimization while significantly reducing in computation.

Conclusion:

In this work, we presented optimization methods in petroleum reservoir management. We demonstrated the performance of each methods separately. From the results obtained it can be concluded that, so far, most optimization studies focus on production optimization as a reservoir management objective.

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