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Optimized Design and Control of Oil Exploitation Strategies: An Assisted Approach

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Abstract

Because there are so many factors and scenarios to consider, optimizing oil exploitation tactics requires complicated decision-making. Conventional approaches frequently concentrate on particular elements of the design infrastructure, which restricts their capacity to fully handle the process. In order to maximize a set of oil exploitation variables in a hierarchical fashion, this research proposes a novel assisted optimization technique that combines mathematical algorithms with engineering analysis. By grouping variables into design, control, and future design groups, the method makes it possible to explore deterministic scenarios effectively with few simulation runs. This methodology's effectiveness in producing high-quality solutions within limited timeframes is demonstrated by applying it to a Brazilian offshore reservoir model that is still in the pre-development stage. The findings highlight how crucial practical engineering analysis and hierarchical variable structuring are to optimizing financial gains. Additionally, the study indicates that assisted optimization greatly lowers computational requirements, which makes it a useful tool for industry practitioners in oil field development strategic planning. To maximize field performance and financial returns, oil exploitation strategies must be optimized. Conventional approaches frequently address discrete elements of the design process while ignoring the relationships among important decision factors. In this work, a new assisted optimization procedure that hierarchically optimizes design, control, and future decision variables is presented. The approach produces optimal solutions with fewer simulation runs by combining deterministic simulations and engineering analysis. When the procedure was used on an offshore reservoir in Brazil, it resulted in notable increases in both net present value (NPV) and recovery factor (RF), with well placement having the biggest influence. This method provides a useful and effective framework for real-world applications by streamlining complex decision-making and lowering processing overhead. The findings open the door for further integration of probabilistic and machine learning techniques and demonstrate the possibility for improved reservoir management. This aided procedure establishes a new standard for oil field development strategy optimization.

Keywords: Oil exploitation strategy, reservoir simulation, assisted optimization, deterministic approach, decision-making, engineering analysis

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INTRODUCTION

For oil exploitation tactics to maximize production while lowering costs, careful planning and decision-making are necessary. The number, placement, and layout of wells as well as their operating schedules are among the engineering assessments and optimization tasks that are part of this process. However, there are difficulties because of the intricacy of reservoirs and the paucity of preliminary data. Current approaches either concentrate on particular factors or are not adaptable enough to handle related design problems. In order to systematically optimize exploitation tactics, this work presents an assisted optimization procedure that addresses and organizes decision factors in a hierarchical manner. An essential part of reservoir management and development planning is the optimization of oil exploitation tactics. Choosing the best course of action frequently necessitates sophisticated approaches that combine engineering assessments with computational optimization techniques because of the intricate interactions between geological, technological, and economic factors. Conventional methods sometimes ignore the interdependencies among decision variables in favor of concentrating on particular elements of the exploitation system, such as platform capacity or well placement. This may result in less-than-ideal tactics that fall short of optimizing a field's recovery factor (RF) or net present value (NPV) [1–3].

This study suggests an assisted optimization procedure that methodically arranges and maximizes decision factors in order to overcome these difficulties. The methodology uses a multilayer, deterministic optimization approach and divides variables into design, control, and future design categories. The most important factors are taken care of first thanks to this hierarchical design, which reduces computing load and enhances solution quality. To improve the decision-making process, mathematical algorithms are integrated with engineering assessments like sensitivity analysis and scenario testing. This study uses the aided optimization approach on a pre-development offshore resource in Brazil. The outcomes show notable gains in NPV and RF, highlighting the effectiveness of the suggested approach.

The study also emphasizes how crucial it is to optimize well placement and strategically sequence decision variables in order to get technically sound and economically feasible results. From the standpoint of reservoir engineering, an oil exploitation plan establishes the essential features of a production system and has a major influence on the field's total financial performance. These features include platform processing capacity and opening timetables, as well as important design components including the quantity, location, and completion of wells. Due to the intricacy of the problem, serial techniques involving estimates, subproblem definitions, and experience-based partial solutions are frequently required. To maximize each element of the exploitation plan, oil corporations frequently use advanced techniques. However, because design and control variables are interdependent, it is still difficult to incorporate these into a holistic plan. Achieving effective solutions requires adequate procedures that methodically arrange and integrate various optimization techniques. This study combines mathematical optimization approaches with reservoir engineering evaluations to create an organized methodology for optimizing oil exploitation options. The method seeks to produce high-quality results in a fair amount of time while minimizing the number of simulation runs needed [4–7]. Variable classification, initial estimates, iterative optimization stages, and final strategy selection are all included in this hierarchical workflow that illustrates the assisted optimization process (Figure 1).

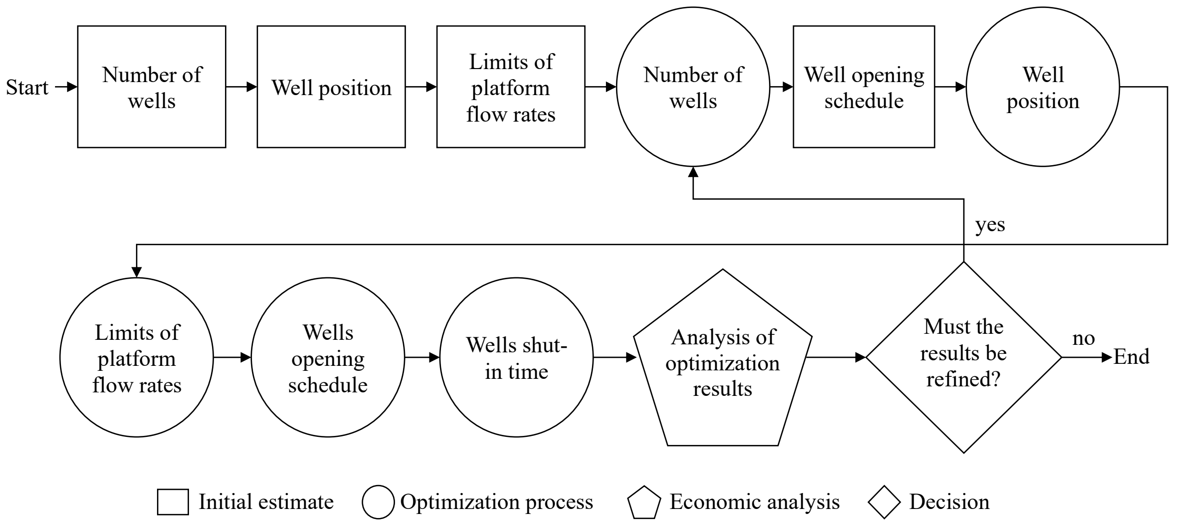

Figure 1. Simplified workflow for assisted optimization process.

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Explanation

An outline of the organized process for maximizing oil exploitation tactics is shown in Figure 1. It highlights the steps in order, beginning with preliminary estimations of the design variables, moving on to iterative refinement procedures (platform flow rates, well placement, etc.), and ending with a refined

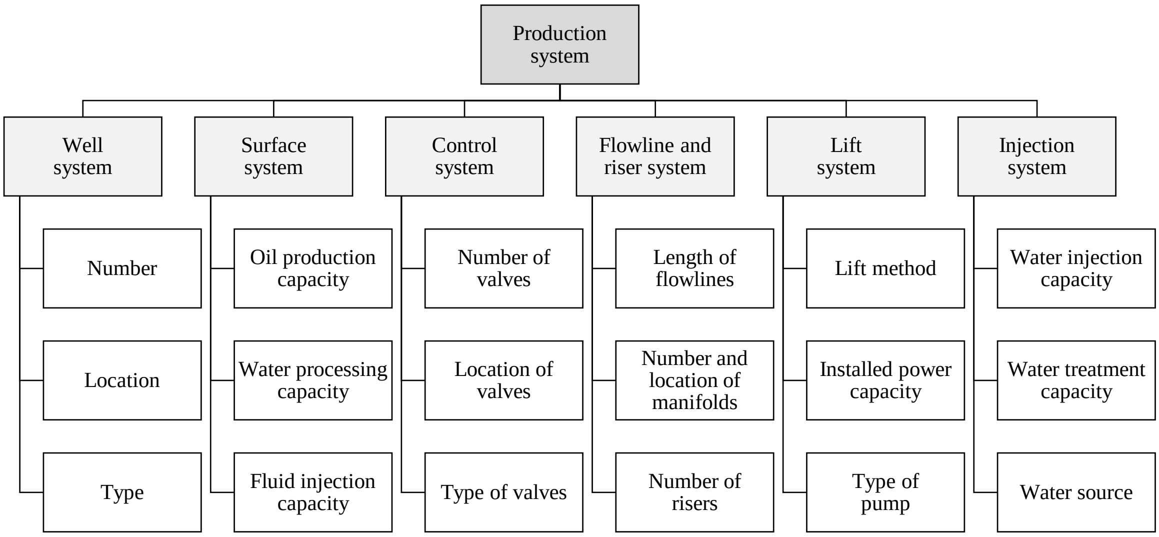

Figure 2. Simplified structural organization chart of production system and decision variables for subsystems.

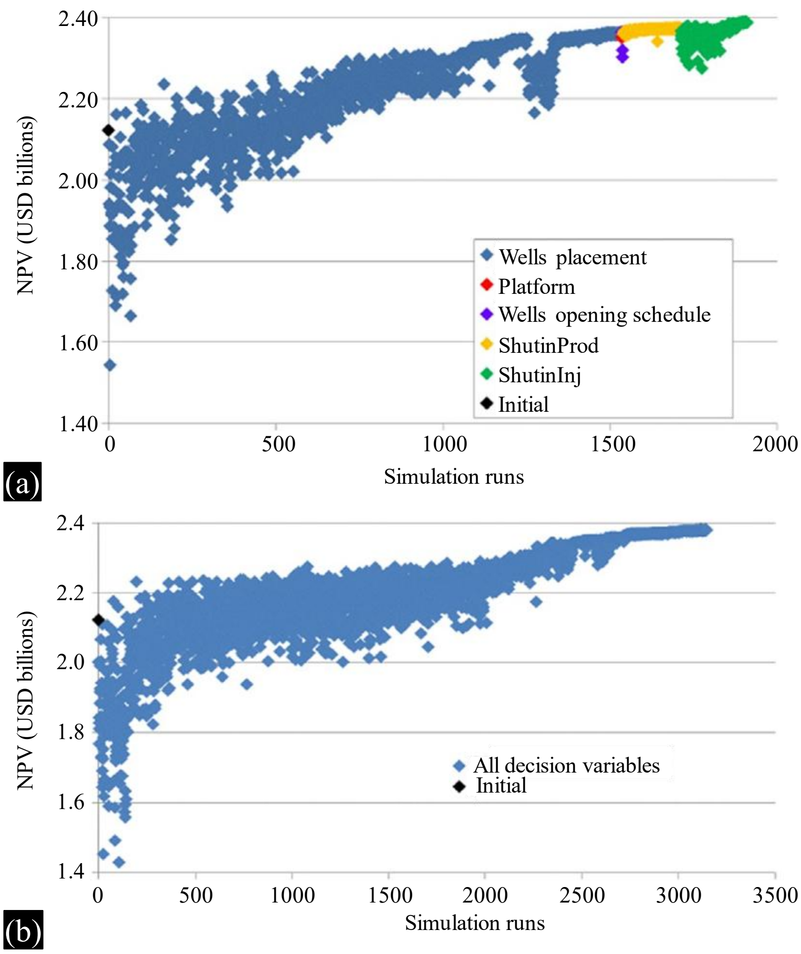

Figure 3. Net present value (NPV) evolution across optimization stages.

approach. The process demonstrates how engineering assessments and optimization methods are combined to provide effective and useful results. Figure 2 shows a simplified structural organization chart of a production system with decision variables for subsystems.

The well system, surface system, control system, flowline and riser system, lift system, and injection system are the main subsystems that make up a production system's hierarchical structure, as shown in Figure 2. To maximize production efficiency, each subsystem has decision variables including number, kind, location, and capacity. System planning, resource allocation, and operational decision-making are all aided by the chart. Improvement in NPV at different phases of the aided optimization procedure are observed. The actions that optimize platform capacity and well location yield the biggest returns (Figure 3).

Figure 3 depicts the incremental increases in NPV at each stage of the optimization process, including well placement, platform flow rate adjustment, and production scheduling. The visualization underscores the relative impact of each stage, with well placement delivering the most significant improvement in economic performance.

METHODOLOGIES

Design, control, and future design are the three categories into which the suggested method divides decision factors. While control variables maximize operational parameters throughout production, design factors, like well sites, are set before field development. Future design factors provide for potential modifications that would necessitate further expenditures. Engineering concepts like sensitivity analysis and variable clustering are incorporated into the process, which employs deterministic simulations to effectively assess various situations. Well locations, production schedules, and platform capacities are iteratively refined after the estimation of basic design variables, which is the first step in the optimization process. Economic metrics like NPV direct decision-making, while computational techniques like the differential evolution with co-evolutionary evaluation (DECE) optimizer help in well placement [8–10]. The proposed assisted optimization process systematically addresses the complexities of oil exploitation strategy design. The methodology involves three main steps:

1. *Variable classification:* Decision variables are categorized into three groups:
    i. *Design variables:* Infrastructure choices, such as well locations, number of wells, and platform capacities.
    ii. *Control variables:* Operational parameters, including well shut-in schedules and flow rate adjustments.
    iii. *Future design variables:* Potential modifications, such as infill drilling or well conversions, to address uncertainties.
2. *Iterative optimization:* High-impact factors (such as well placement) are the first in a hierarchical approach. Optimization choices are guided by economic analyses, such as NPV and deterministic reservoir simulations. Sensitivity analyses prioritize important judgments and fine-tune the variable clusters.
3. *Engineering analysis integration:* Engineering analysis integration refers to the seamless combination of computational tools, simulations, and data analysis within engineering workflows to enhance efficiency, accuracy, and decision-making.

Applications

This methodology is applicable to:

- *Field development planning:* Optimizing well locations, platform capacities, and production schedules for both onshore and offshore reservoirs.
- *Production strategy refinement:* Improving the performance of mature fields by optimizing operational parameters.
- *Economic evaluations:* Enhancing profitability by maximizing NPV while considering operational constraints.

Future Aspects

To further enhance the robustness and adaptability of the assisted process, future research should focus on:

- *Probabilistic optimization:* Incorporating uncertainty modeling for geological and economic factors.
- *Machine learning integration:* Using advanced algorithms to predict optimal strategies and reduce simulation times.
- *Dynamic field management:* Developing real-time optimization frameworks to adapt to changing reservoir conditions and market dynamics.
- *Sustainability metrics:* Integrating environmental considerations, such as carbon emissions and water usage, into the decision-making process.

This forward-looking approach will ensure the methodology remains relevant and effective in the evolving energy landscape.

DISCUSSION

By lowering computational requirements and facilitating the investigation of more situations, the aided approach greatly improves reservoir management decision-making. By successfully applying the concept to a model of an offshore reservoir in Brazil, it was demonstrated that fewer simulation runs might yield optimal results. This methodology could be expanded in future applications to include probabilistic scenarios that handle economic and geological concerns. The accuracy and speed of optimization activities could be further enhanced by sophisticated machine learning models [12–15].

CONCLUSION

This study shows that the selection of oil extraction tactics can be efficiently streamlined through the use of an organized, supported optimization process. This method improves efficiency and financial returns by classifying decision variables and utilizing deterministic simulations. For more reliable and flexible solutions, future research should concentrate on improving optimization algorithms and incorporating probabilistic assessments. The transformative potential of an assisted optimization process in the design and refinement of oil exploitation techniques is demonstrated in this work. The methodology offers a structured framework that streamlines complex decision-making by methodically grouping decision variables into design, control, and future design groups. Efficiency is greatly increased by combining engineering assessments with deterministic simulations, which minimizes calculation time while optimizing financial returns like NPV and RF. The application to an offshore resource in Brazil demonstrated the significance of well placement optimization, which produced the largest NPV increases. Additionally, a comprehensive and realistic exploitation plan was guaranteed by the continuous improvement of platform flow rates and production schedules. This strategy handles interdependencies holistically, offering a more resilient and adaptable solution than previous approaches, which frequently concentrate on single factors. The findings highlight how little adjustments to well layouts can result in major operational and financial benefits. In addition to improving existing field development strategies, this process creates the framework for future research that incorporates probabilistic situations and cutting-edge machine learning techniques. This method provides a crucial tool for contemporary reservoir management, guaranteeing lucrative and sustainable operations, thanks to its ability to enhance decision-making under ambiguity.

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