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UNISIM ON-LINE

YEAR 14, NUMBER 8
135TH EDITION
NOV, 2019

INFLUENCE OF WELL AND GATHERING SYSTEMS PARAMETERS ON INTEGRATED PETROLEUM RESERVOIR AND PRODUCTION SYSTEM SIMULATIONS

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> *"Using a reduced number of variables, we can effectively evaluate oil production and indicate decisions to be made for production management."*

Introduction

The productivity of an oil field is one of the most uncertain indicators of the oil industry. At the beginning of its production, only with seismic data, testimonies and pioneer wells, for example, predictive simulations of field productivity are made. In these simulations, the focus is on the reservoir and the production system is not normally considered. However, to reproduce results closer to reality, the integration between the two systems must be considered.

Boundary conditions of production systems are usually oversimplified and field production forecasting essentially simulates reservoir behavior. These simulations can potentially lead to errors in the production and financial return due to undersizing or oversizing production systems. Integrating analyses of reservoir and production systems means more consistent simulations and more accurate NPV (Hohendorff Filho and Schiozer, 2014; Victorino *et al.*, 2018). High levels of detail are needed to integrate reservoir and production systems to decrease uncertainties and discontinuities, but this situation is complex to simulate because of higher computation times and effort, and convergence problems. These issues require more studies to provide representative and efficient integrated analysis tools for the oil industry. In this work, we use a decoupled sensitivity analysis to develop the production system focusing on well and gathering systems and then performed an integrated sensitivity analysis between reservoir and production system to define the impact of configurations, performance and production strategy for this field.

Methodology

The step 1 is a decoupled sensitivity analysis of well and gathering system parameters. The step 2 uses the most influential parameters from Step 1 in an integrated sensitivity analysis between reservoir and production system (well and gathering system). The two steps are complementary. Step 1 considers fixed reservoir information for use in the simulations, evaluating selected parameters and their impact on the production of this field. The criterion to measure the importance of sensitivity for a considered parameter is the value correlating to response surface (RS) for QO (oil flow rate – m³/day), using the response surface methodology (RSM). We perform a full experimental design for all parameters considered in both steps. The first step reduces the number of the parameters for inclusion in the integrated simulations and so greatly reduces the computational time. Step 1 indicates the parameters that can be evaluated by production rates, which may or may not increase NPV and so does not guarantee financial return. Step 2, using the most sensitive parameters, provides the project NPV with the production suitable for each study case. The integration step considers a simplified economic analysis to evaluate the objective function, NPV. The criterion of sensitivity importance for a considered parameter is RS values correlated with NPV, using RSM. The proposed method evaluates the impact of parameters on objective functions (Qliq and NPV), that may not be correlated. Pareto analysis, that quantifies the degree of importance of each parameter for selection, could be analyzed to take into account the behavior of the objective function, allowing the exclusion of parameter levels with low response values. This was not done in this study. The methodology was applied to the parameter limits considering all possible combinations to show the complete set of the results, although for some combinations make less sense physically (worse expected results).

Application

This study uses the reservoir model from the UNISIM-I-D benchmark case maintaining the same environmental conditions (reservoir pressure and temperature) for each well and same geometry with the base scenario of the satellite wells. We consider only one type of fluid (black oil model), which is under the same conditions. Empirical correlations of the multiphase flow behavior by Beggs and Brill and Standing are used to model fluids. The basic well and gathering systems comprise 12 producer and 6 injector wells, all of which are satellite wells. The analysis is separated into design parameters (combinations of pipe diameters (in): Col - production column; FL - flowline and RI - riser); operational parameters (gas lift flow rates - Qgi (m³/day) and the downstream - wellhead pressure – Pj (kgf/cm²)); and uncertain variables, bottom-hole conditions (gas–liquid ratio – GLR (m³/m³) and water cut – Wc (%)). The analysis considers these parameters, most used in submarine well and gathering systems, taking into account all the simplifications adopted in the study. The wells chosen for analysis were PROD05 and PROD010, which are similar and representative of the field. PROD05 is the farthest and PROD010 is the closest to the platform. What differentiates each well is their distance to the platform.

Results and Discussion

Decoupled sensitivity analysis

We evaluated all parameters and their influence on the oil production using RSM. The criterion of sensitivity for a considered parameter is value variations between ± 10% for RS value of Qo, evaluating both wells. The results are shown in Tornado charts. Figure 1 shows the parameter evaluation for well PROD05 and Figure 2 for well PROD010.

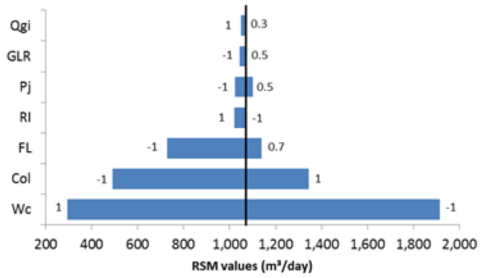

Figure 1: *Verification of the sensitivity analysis of parameters and influence on the oil production (QO) of the satellite well PROD05.*

For well PROD05, we observed that Col and FL diameters greatly impacted the oil production rate, but the RI diameters did not have impact on production. The operational parameters (Qgi and Pj) also had little influence on production. In relation to well PROD010, we noted behavior similar to well PROD05, Col and FL diameters impacted the production, RI diameter also influenced production for this well unlike PROD05.

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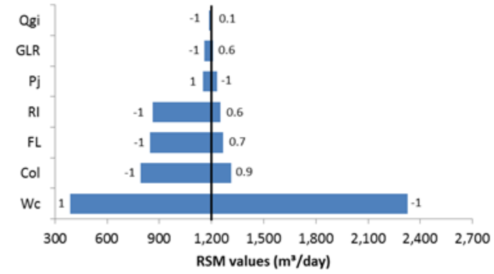

Figure 2: *Verification of the sensitivity analysis of parameters and influence on the oil production (QO) of the satellite well PROD010.*

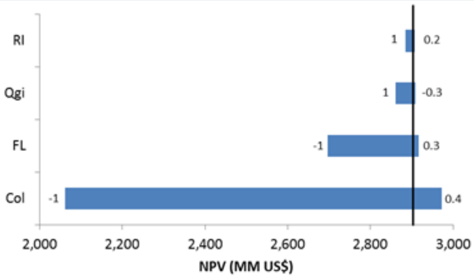

Figure 4: *Verification of the sensitivity analysis of parameters and influence on NPV for integrated reservoir and production systems.*

> *"The integrated analysis showed more realistic results for the production of this field, in an analysis combining oil production and financial return."*

We observed a trend, in the step 1, for increased productivity in combinations of larger pipe diameters. Wc presented the greatest influence on the production among the uncertain variables as well as the other design and operational parameters. The GLR parameter promoted low impact on production (discarded for step 2). Qgi although did not have impact on production, but is considered in the next step due to their importance to mitigate production instabilities. This analysis contributed to reduce the number of parameters for step 2.

Integrated sensitivity analysis

This step considers all wells in the integrated system. The lowest wellhead pressure (10 kgf/cm2) resulted in the highest liquid production (fixed value in this step). By step 1 the parameters Col, FL, Qgi and RI are evaluated. Wc changes because of variations in reservoir conditions. Figure 3 shows the simulated NPV for integrated systems with the 27 combinations of diameters and for the three gas lift flow rates considered.

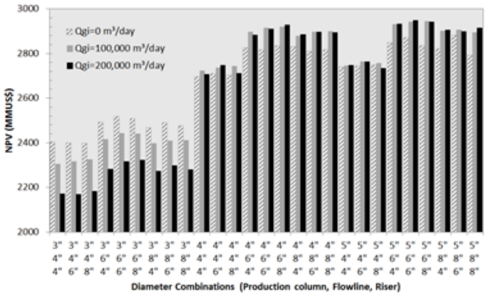

Figure 3: *Integration evaluation for all combinations of diameters and gas lift injection flow rates and respective NPV.*

Figure 4 (Tornado chart) synthesizes this evaluation considering the parameters chosen based on the results of step 1. The best choice is based on the highest NPV not the highest productivity. The most influential production parameters should consider these two analyses (decoupled and integrated) together. The criterion of sensitivity for a considered parameter is value variations between ± 5% for RS values of NPV. This way, verifying the influence of the parameters in real time and observing changes in the NPV, Col and FL had a significant impact. The two steps are differentiated by dynamic changes in the reservoir, which are considered in step 2. If we included all system parameters, unfiltered, in the step 2 would result in an excessively high, and therefore unfeasible, computational time.

Using integrated system simulations considerably reduces the search space in an optimization process of production strategy. Combination with Col=5", FL=6", and RI=6" and Qgi=200,000 m3/day presented the highest NPV, that could be selected. The methodology (choice of appropriate variables) reduced computational time and is easy to use to evaluate projects. It can lead to feasible solutions to determine a production strategy for various oil fields.

Conclusions

Decoupled sensitivity analysis identified parameters with the most impact on the production system. The analysis was complemented in the integrated step. The other producer wells had the same characteristics as those in the step 1 due to similar conditions and properties. Therefore, the results are more robust and more realistic. These better results consequently promoted modifications in the integrated system to develop a better production strategy. The integrated analysis showed that in some cases, even if the reservoir shows good production, there is no guarantee that there is a production system affordable for those conditions and so, the production system should be considered as a boundary condition for the reservoir simulation. The flexibility in using explicit integration allows new opportunities to find better ways to improve the prediction of optimized production management in fields with production and injection fluids. This methodology allows the reproduction of scenarios closer to the production of real fields. We can reduce the number of parameters that impact production, achieving more robust simulations by considering the real-time dynamic changes and limits of the reservoir. There is a decrease in computational time which is a critical factor for integrated simulations. This allows to obtain different means to modify the production and increase financial return.

References

Hohendorff Filho J.C.V, Schiozer D.J. 2014. Evaluation on explicit coupling between reservoir simulators and production system. J Energy Res Technol 136(4):1–24.

Victorino, I.R.S., Hohendorff Filho, J.C.V., Castro, M.S., Mello, S.F. and Schiozer, D. J. 2018. Influence of well and gathering systems parameters on integrated petroleum reservoir and production system simulations. Journal of the Brazilian Society of Mechanical Sciences and Engineering (2018) 40:435.

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