UNISIM ON-LINE
UNICAMP
Year 16, Number 3 | 144th edition | September, 2021

Well Management in the Development of Integrated Multiple Reservoir Sharing Production Facilities*

João Carlos Von Hohendorff Filho

"The project control variables exerted an important influence on the economic return and production strategy selection, especially for multiple reservoirs with different fluids sharing a surface facility."

Bento and Schiozer (2010) demonstrated that the gas flow limit is an operational restriction that influences the selection of the production strategy and, the lower the gas capacity, the greater its influence on the production strategy.

Cotrim et al. (2011) demonstrated that, for a case that was subject to gas production limitation - the apportionment allocation rule, which prioritizes the restriction of wells with higher GOR (gas-oil ratio) - provided higher profitability to the project, evidencing the need to study the definition of the best reservoir management strategy on a case-by-case basis.

Gramorelli et al. (2018) revealed a small gain through the application of different strategies for the apportionment of a well's flow rate, prioritizing the restriction of wells according to selected parameters. For the case studied, where there is a great difference between the GOR of the reservoirs and the impact of the gas restriction, it is noticeably high in the production of light oil with high GOR, the strategy that prioritizes the restriction of wells with higher instantaneous gas flow is the most profitable. GOR control was not effective in handling this valuation. The authors also commented that to optimize the results of shared production, one option is to use the explicit coupling between the models through an external tool that controls well group management.

Objective

The objective of this study is to verify the impact of well management in field development using integrated models and an economic evaluation based on the distinct prioritizations by reservoir, with different fluids.

Methodology

We first assessed development decision changes for the production phase, comparing design parameters, control parameters, and performance results from an optimized production strategy for a representative model. This concept is common in decision-making processes based on models, as it avoids poor choices leading to incorrect conclusions.

We expanded the assisted optimization workflow by von Hohendorff Filho and Schiozer (2018) to clarify the methodology. After optimization processes without integration, we define a step for production system integration with reservoir.

We use an integrated explicit model case based on two reservoirs with different stream oils, with production and injection constraints in the shared platform. The independent reservoir models are tested on three different well management approaches for platform production sharing, evaluating their impact in field development.

The benchmark UNISIM-I&II consists of two reservoir models (Arenito and Carbonato), which in turn are based on the benchmark cases UNISIM-I and UNISIM-II, already published separately, and a production system model. The dataset includes reservoir simulation models, data related to the production system model, and the adopted economic scenario.

Approach 1 uses fixed apportionment of platform production and injection capacities, common to integrate multiple reservoirs in separate simulations (Bento and Schiozer, 2010). We apply static percentages for production and injection capacities for each reservoir separately. Approach 2 uses dynamic flow-based apportionment, common in joint integrated simulations. We use WellPrior methodology (Cotrim et al., 2011) with the addition of a term in the denominator to allow its application in more case studies, with a differentiated form in the treatment of wells that exceed the rate flow. Approach 3 uses a modified dynamic flow-based apportionment, including economic differences, using weights for each reservoir as a specific case for joint integrated simulations. We propose a percentage multiplier weight for the WellPrior value calculation inside coupler, applied to all wells for each reservoir. With this method, we try to incorporate the effect of different economic values of oil streams.

Results

In this study we found significant differences between the values of Np, Gp, Wp, Wi and production strategy (**Table 1**). We observed a significant difference in field recovery, but not in NPV. The major differences were related to how the optimization process considered the Carbonato reservoir. The best well management prioritized oil production from the Sandstone reservoir at the expense of the Carbonato reservoir.

***Table 1**: Reservoir performance and objective function results from the optimization procedure for all approaches.*

Approach	Reservoir	Np 10^6m^3	Gp 10^9m^3	Wp 10^6m^3	Wi 10^6m^3	NPV 10^9US$	Wells
1	Arenito	53.2	6.0	20.2	92.5	1.11	11
	Carbonato	72.9	17.0	27.8	138.1	2.25	12
	Field	**126.0**	**23.0**	**48.1**	**230.6**	**3.36**	**23**
2	Arenito	54.5	6.2	24.4	98.4	0.68	13
	Carbonato	86.3	20.2	49.2	179.3	2.58	19
	Field	**140.8**	**26.3**	**73.6**	**277.7**	**3.26**	**32**
3	Arenito	55.5	6.2	27.9	103.6	0.94	13
	Carbonato	86.0	20.1	51.3	181.5	2.44	19
	Field	**141.5**	**26.3**	**79.2**	**285.0**	**3.38**	**32**

Approach 1 rendered the intermediate NPV compared with the other approaches. On the other hand, it provided the lowest oil recovery. We observed that the exclusion of several wells in the light oil field led to a good valuation of the project due to a reduction in the CAPEX and OPEX, even with these wells producing a fluid with better value. In addition, the platform had never reached its oil and gas constraints and had production potential (**Figure 1**).

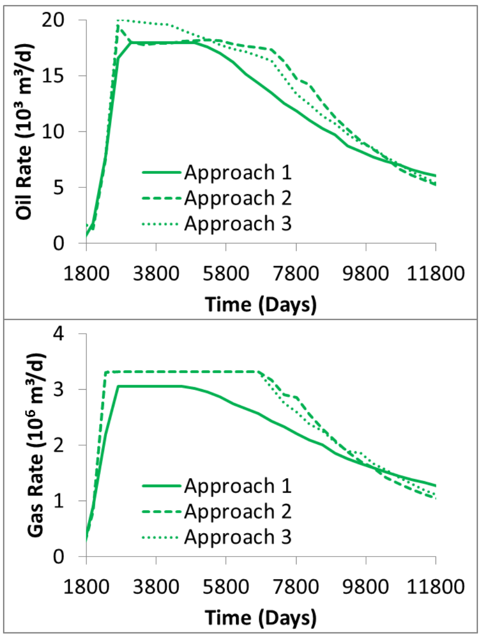

***Figure 1**: Oil (upper) and gas (lower) field production forecasts for Approaches 1, 2 and 3.*

Approach 2 provided the lower NPV performance in this case, and the intermediate oil recovery. We found that the well prioritization, based on flow, failed to capture the

Specials interests:

- UNISIM
- UNISIM Publications
- Reservoir Simulation and Management Portal
- Previous Issues

Links:

- UNICAMP
- Cepetro
- Petroleum Engineering Division
- School of Mechanical Engineering
- Petroleum Sciences and Engineering

Graduate:

Petroleum Sciences and Engineering: interested in Masters and PhD in the Simulation and Oil Reservoir Management area click here.

"Apportionment allocation rule, which prioritizes the restriction of wells with higher GOR - provided good financial return to the Project. However, to apply the economic differences using weights for each reservoir for all the fluids increased NPV."

effects related to the different valuation of the fluids produced by the two reservoirs. The well management for gas restriction leads to uniform prioritization for gas flow between both reservoirs, and it did not take into account the type of oil, unlike Approach 1 (**Figures 2 and 3**).

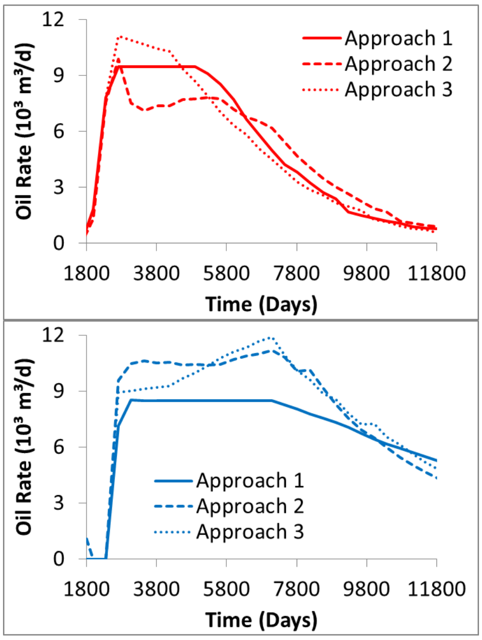

Figure 2: *Oil productions for the Arenito (upper) and Carbonato (lower) reservoirs for Approaches 1, 2 and 3.*

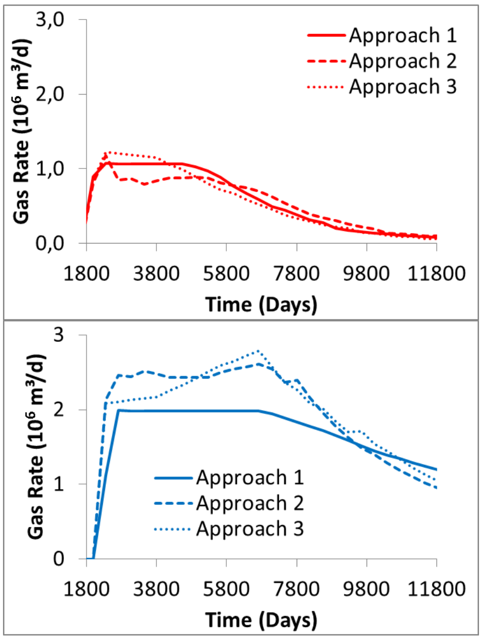

Figure 3: *Gas productions for the Arenito (upper) and Carbonato (lower) reservoirs for Approaches 1, 2 and 3.*

Approach 3, which handled the type of fluids similarly to Approach 1, provided the greater NPV and oil recovery than the other approaches. The weight for each reservoir applied to the well prioritization better captured the gains related to different valuation of the fluids produced by the two reservoirs. Dynamic prioritization with weights performed better results than the fixed apportionment for shared platform capacities (**Figures 2 and 3**).

The best well management prioritized oil production from the Sandstone reservoir, instead of the Carbonato reservoir, even with the Carbonato reservoir's oil price.

Discussion

Well management based on gas flow with a weight applied to each reservoir provided a greater oil recovery (+0.5%) and NPV (+3.9%) than the simulation with production flow management based on gas flow only. Prioritization of well flows played a fundamental role in the performance of the integrated field, affecting the location of wells. Other optimization parameters had very similar values, indicating little impact on the optimization.

We observed that the project control variables exerted an important influence on the economic return and production strategy selection, especially for multiple reservoirs with different fluids sharing a surface facility. This result serves as the basis for deciding when it is necessary to perform a more thorough analysis of well management.

For the case studied subject to gas production limitation - the apportionment allocation rule, which prioritizes the restriction of wells with higher GOR - provided good financial return to the project, evidencing the need to define reservoir management strategy on a case-by-case basis. However, to apply the economic differences using weights for each reservoir for all the fluids increased NPV.

Conclusions

A relevant impact on the choice of the optimization strategy of the management variables in the field development project was observed, changing well management routines for the studied approaches and affecting the oil recovery factor and production strategy.

Well management algorithms implemented in traditional simulators are not developed to prioritize different reservoir wells separately, especially if there are different economic conditions, exemplified here by different valuation of produced fluids. This valuation should be considered in the short-term optimization for wells, and in this study were possible using developed tools as our own coupler.

References

Bento, D. F., Schiozer, D. J. (2010). The Influence of the Production Lines Pressure Drop in the Definition of the Oilfield Drainage Strategy. doi:10.2118/138259-ms.

Cotrim, H. A., von Hohendorff Filho, J. C., Schiozer, D. J. (2011). Production Optimization Considering Interaction between Reservoirs and Constrained Surface Facilities. doi:10.2118/148334-ms.

Gramorelli, F.; Hohendorff Filho, J. C. V.; Schiozer, D. J., (2018). Gerenciamento Integrado de Múltiplos Reservatórios Sujeitos a Restrições Operacionais e de Escoamento, Rio Oil & Gas Conference, September 24-27, Rio de Janeiro, Brazil.

*Hohendorff Filho, J. C. V.; Schiozer, D. J. (2020) Influence of Well Management in the Development of Multiple Reservoir Sharing Production Facilities. doi: 10.2516/ogst/2020064.

von Hohendorff Filho J.C., Schiozer D.J. (2018) Effect of reservoir and production system integration on field production strategy selection. doi:10.2516/ogst/2018042.

About the author:

João Carlos von Hohendorff Filho holds a B.Sc. in Civil Engineering from UFSC, a M.Sc and PhD in Petroleum Sciences and Engineering from UNICAMP. He is a researcher at UNISIM/CEPETRO/UNICAMP since 2013, working on simulation and integration between reservoir and production system.

UNISIM opportunities:

If you are interested in working or developing research in the UNISIM Group, please contact us.
For further information, click here.

UNISIM

Research in Reservoir Simulation and Management Group

Petroleum Engineering Division - Energy Department
School Of Mechanical Engineering
Center for Petroleum Studies
University of Campinas
Campinas - SP

Phone.: 55-19-3521-1220
Fax: 55-19-3289-4916

unisim@cepetro.unicamp.br

The UNISIM Research Group is part of UNICAMP (Petroleum Engineering Division, Energy Department, School of Mechanical Engineering, Center for Petroleum Studies) that aims to develop Works and projects in the simulation and reservoir management area.