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Well and ICV Management in a Carbonate Reservoir with High Gas Content

Vinícius Eduardo Botechia

Introduction

This text summarizes the paper of Botechia *et al.* (2021), which proposes a methodology using reactive control rules for producers and ICVs, with GOR as monitoring variable, to improve the economic performance of the field.

The management of oil fields is a complex activity with very challenging phases. When in the production phase, some challenges are related to undesired fluids, since their production directly impacts the project's incomes. The excessive production of these fluids may reach the platform capacity and, therefore, be a bottleneck for oil production and economic return.

In fields with light oil and high content of CO_2, such as the ones from the Brazilian pre-salt, the production of gas tends to be elevated. Thus, to deal with this issue, the use of Interval Control Valve (ICV) as a flow control device can be an alternative to improve the production and economics of the field.

Although a promising device, the control of ICVs is not trivial. The optimal response of these devices is dependent on the wells and reservoir characteristics, and these may vary over time.

Our objective in this work is to improve the economic return of projects developed in fields with similar characteristics to the Brazilian pre-salt via optimization of production strategy in the management phase. Our methodology compares the control of wells (producers shut-in), ON-OFF ICVs and multi-position ICVs. Most of works related to ICV optimization aims to optimize the ICV operation itself, by closing the valves over the time. Here we intend to perform the control in a different way, by finding the best control rule (in this case, monitoring GOR), instead of simply closing the ICVs over time.

Methodology

In this work, comparisons are made with production strategies that consider:

a) control of the wells (here referring to shut-in producers when they reach a determined value of GOR);

b) control of ON-OFF ICVs (similarly, shutting down zones when they reach a determined value of GOR); and

c) control of multi-position ICVs (between a specified range of GOR values).

The GOR limit for closing wells or ICVs is determined by optimization algorithm. In this work, we use the Iterative Discrete Latin Hypercube (IDLHC - Hohendorff Filho *et al.*, 2016). The first step is to define the parameters to be used in the optimization, such as the search space (variables and their range of values) and algorithm specificities (number of samples per iteration, number of iterations, and threshold cut value).

The procedure is very similar for items (a) (well control) and (b) (ON-OFF ICV control), and the main difference concerns the definition of the optimization parameters. In the case of well control optimization, the number of variables is equal to the number of producers, while in the case of ICVs optimization, the number of variables is higher since there are more than one ICV per well. For item (c) (multi-position ICVs), we verify whether it is beneficial to partially close the ICVs in different levels over time. Here, we initially considered the following assumptions for the optimization step: (i) we used five positions for ICVs (ranging from 1, meaning fully open, until zero, meaning fully closed and (ii) the closing process starts with 70% of selected GOR (a sampled value of the optimization process) and finishes (ICV fully closed) with 20% more of selected GOR.

Results

Figure 1 shows the evolution of the field NPV during the optimization process for well control, while Figure 2 and Figure 3 shows the evolution of NPV for the optimization of ON-OFF ICVs and multi-position ICVs, respectively.

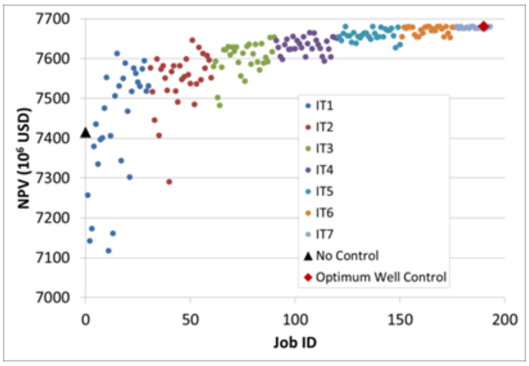

***Figure 1**: Evolution of the NPV over the simulation jobs for well control optimization in all iterations (IT).*

***Figure 2**: Evolution of NPV over the simulation jobs for ON-OFF type ICV control optimization in all iterations (IT).*

***Figure 3**: Evolution of NPV over the simulation jobs for multi-position type ICV control optimization in all iterations (IT).*

It can be noted that all situations improved the economic return of the field in relation to the case without any control. However, the use of ICVs promoted a much higher improvement (about 8%) in relation to the case when only the whole wells shut-in due to high GOR.

The closure of the ICVs not only affects the performance of the well itself, changing the fluid flow among the zones, but also affects the surrounding wells, therefore contributing to enhance the performance of the entire field.

For all control rules, we observed that some zones, or wells, tended to close with lower GOR values than others. In general, we observed that this happened with less productive wells, which were interfering with other more productive and efficient well.

Figure 4 shows the relative differences in NPV, cumulative oil, water and gas production, considering different types of field management (only well control, ON-OFF ICVs control, and multi-position ICVs control). In this case, the relative differences are measured in relation to the case without any control.

It is possible to stress the great improvement in both economic and production indicators when using ICVs for the management of the field, increasing the NPV by 12% and the cumulative oil produced by 18%, while the well shut-in management could improve the NPV and cumulative oil production by only 3% and 5%, respectively. The use of multi-position ICVs presented a slight better result than ON-OFF ICVs.

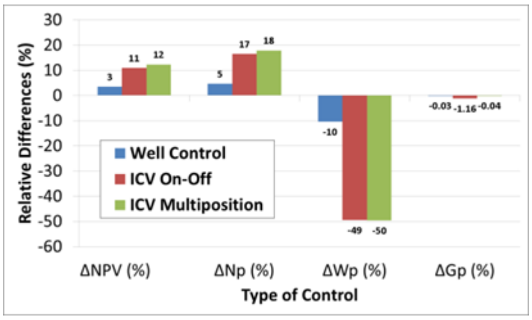

***Figure 4**: Relative differences for NPV, cumulative oil, water and gas production, considering different types of field management.*

We stress that, despite the fact that the main concern for this studied case is the high amount of gas production, the differences in this indicator were very small, which means that in all cases the platform was operating in full capacity (limited by gas). However, the main benefit of the ICV control (significant improvement in oil production) was caused mainly due to zone or well interference. As previously mentioned, shutting down some less productive zones/wells improved the production of other zones/wells, which reflected in the increase of the economic return of the project.

Conclusions

In this work, we compared the performance of a field through its management in different ways: only with control of producing wells (shutting down those that were impairing the field performance) and with the use of ICVs and their control. For both cases, control rules (using GOR as a monitoring variable) were successfully applied to find the optimal closing point of the wells or valves.

For the studied case, the use of ICVs was extremely beneficial for the performance of the field, rather than only the well shut-in management. We compared the use of ON-OFF and multi-position ICVs. Both types achieved similar results, with a slight advantage of multi-position ICVs. The best benefit regarding the use of ICVs occurred due to the high interference between the wells, and the closure of some zones in some less productive wells significantly increased the production of other wells, which reflected in a substantial improvement in the economic return of the project.

Acknowledgments

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“ICVs can be a good alternative to improve production and economics for fields limited by gas production.”

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