Comprehensive Validation of Current Field Development and Production Operation Strategy with Integrated Asset Modeling Approach

Introduction

To identify the full potential of a brown field, it is crucial to be able to validate its existing field development and production operation plan, as well as to evaluate the feasible development strategies to further enhance oil recovery. It is also important to make the right decision to operate the asset safely and to optimise the overall reservoir recovery. These evaluation and assessment require inputs and close interaction across different domains, to reduce any potential gaps and to optimize its final decision making with considerations of various operational as well as economic factors.

By adopting an integrated asset modeling approach, it enables the ability to bring various component models under one platform and subsequently allows one to accomplish an inclusive development planning study with consideration of optimized well placement of both producers and injectors (water or gas), requirement of new process units such as separator, pumps or compressors to accommodate the increased production.

This paper presents how an integrated asset model for an onshore brown field was developed to enable a comprehensive validation of the current field development strategy and its downstream process plant operation plan to ensure safe and efficient operation; as well as assessment of other possible development scenarios to fully realise the potential of the studied asset. The challenges faced were to identify the optimal development plan with minimal well count and maximum recovery.

The integrated asset model as presented in Figure 1 provides a pore to process closed loop solution, i.e. from reservoir to process facility plant, taking into account of reservoir, wells, pipelines, process handling capacities, operating constraints and constraints imposed by both injection and production networks. The study demonstrates that a comprehensive validation of the existing development and operation strategy is achievable with an integrated asset modeling approach. Along the study, it is also concluded that a further improved oil recovery can be achieved with a 40-years of field development instead of the original planned of 20-years.

With the developed integrated asset model, this paper also describes the benefits of a closed loop pore to process solution for the studied under-saturated oilfield to achieve its optimal reservoir recovery and safe operating plan. The integrated asset model have a compositional reservoir model coupled to compositional well and network model that connects to a downstream process facility model. The product streams of available gas and water for re-injection are connected to both the gas injection and water injection networks, which coupled to the reservoir injectors. A compositional integrated asset model enables better tracking of fluids from reservoir to wells, pipelines, process separators through to the process product streams (as shown in Figure 2). It allows monitoring of flow assurance indicators for bottlenecking and erosional velocity limits, apart from providing all essential valuable inputs to business processes for optimal asset management, faster and more accurate decision making, and breaking the barrier of hydrocarbon flow path from sand face to the export points.

Method and/or Theory

The representative integrated asset model of the studied brown oilfield was developed with a well-established commercial field development planning and operations software application. It dynamically links a complex reservoir, multiple interdependent wells, pipelines networks and process models together into one single platform. The integrated asset modeling platform includes both gas and water reinjection network models to provide a pore to process closed loop solution. Below listed are the main component models of the developed integrated asset model:
- 1 compositional history-matched reservoir model (of > 30 producing wells, and water injectors and gas injectors)
- 1 calibrated production wells and pipelines network model (built on GIS map)
- 1 newly built and calibrated process facility model
- 1 gas-reinjection network model
- 1 water-reinjection network model
- EXCEL spreadsheet
- 5 different embedded Variable Equation utilities for some simple and ad hoc calculations.

**Figure 1** The integrated asset model consists of reservoir model, production wells and pipelines network, process facility model and both water and gas reinjection network models.

The availability of this fully integrated asset model with up-to-date calibrated wells and network models and process model enables engineers to better understand the current well performance and production potentials and to identify any possible bottlenecks imposed by the large complex surface network and process facilities. It also allows the asset teams to evaluate different development and operating scenarios to further enhance well performance and the overall asset productivity via determining location of infill wells and which unused idle producers to be converted to gas / water injectors, and obtaining a comprehensive understanding of well integrity and flow assurance studies.

**Figure 2** The simulated fluid compositions of the commingled production streams
The Base Case of the studied asset (also known as Field Scenario 1, FS1) with the current field development and operating strategy incorporated, i.e. no additional field actions apart from those approved and implemented in the existing operation as below listed:

- Routine annual all wells shut-in in September.
- Field operation with different set total field production gas targets in summer and winter months;
- Having injection gas rate constrained at the set limits (to ensure operation within the process unit capacity and operating envelope).
- Well controlling and prioritisation based on flow conditions like gas-oil-ratio (GOR) or watercut.

The objectives of integrating the process facility model are of the followings:

- To determine the forecasts for all of product streams (downstream of the process plant), i.e. export gas, condensate, crude oil for export, disposal water/ water for reinjection etc. throughout the field lifetime.
- To determine the forecasts of energy consumptions for the interested key process units, i.e. compressors.
- Lastly the most important one – to determine any bottlenecks of the process facility (gas process line, water process line, liquefied petroleum gas (LPG) process line etc.) and to fully understand how to incorporate these impacts to capture a more realistic picture of the entire asset performance.

The aforementioned Base Case is further extended with incorporation of modified operating conditions and set constraints to assess 2 alternate field development scenarios:

- Field Scenario 2 (FS2) – to investigate if improved oil recovery is achieved with additional 1 gas and 2 water injectors (converted from the identified producers), 4 additional infill wells, with set gas injection and water injection capacity constraints.
- Field Scenario 3 (FS3) – to validate the optimal field development strategy identified from the reservoir standalone field management study: with 3 additional gas injectors and 1 further added infill producer of those implemented in FS2, with new set gas injection and water injection capacity constraints.

In each field scenario study, the simulated results such as volumetric production flowrates (gas, oil and water) of the coupled production wells are presented graphically as visualisation of the coloured profiles eases the analysis, as illustrated in Figure 3 below. Other parameters like mass rates, gas-oil-ratios and watercuts, and the mapped mole fractions can also be presented in the similar way for a comprehensive analysis.

![Figure 3 The simulated volumetric flowrates (gas, oil and water) of the coupled production wells](image)
Conclusions

An integrated asset model has been developed for the studied onshore brown oilfield that links the reservoir, wells and pipelines production network, process facility model as well as both the gas and water reinjection networks. The availability of fully integrated asset model with pore to process solution enables engineers to better understand the current well performance and production potentials and to ensure a safe and optimal process plant operation.

This integrated asset model helps to identify bottlenecks imposed by the existing pipelines network and process facility; it also enables the asset team to validate the existing development plan. Multiple integrated asset models delivered in this study have established some good baselines which allows PGNiG engineers to evaluate various field development scenarios comprehensively, to enhance reservoir performance, the overall asset productivity and the ultimate oilfield recovery via determining location of infill wells and detecting which unused idle producers for conversion to gas or water injectors. The studied field development scenarios are with full consideration of well and network integrity issues and assurance of a safe and optimal process plant operation.

The integrated asset model can be an evergreen model by continuously maintaining its individual sub models and re-integrating into the integrated asset model. This will ensure that any deviations from the forecasted results are addressed in a proper and timely manner; and the development plan is continuously managed and adjusted for maximum return on investment.

The study demonstrates a comprehensive validation of the existing development and operation strategy is achievable with the approach. It also concludes that an improved oil recovery can be achieved with a 40 years of field development instead of the original 20 years plan.

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References

