CASE STUDIES

MULTI WELL ALLOCATION USING DIGITAL OIL FIELD (DOF) TECHNOLOGY IN THE NORWEGIAN SEA

Introduction

The Tyrihans field is located in the Halten Bank area of the Norwegian Sea, 35km south-east of the Kristin field in roughly 285m of water. The discovery is comprised of two structures—Tyrihans North, a gas condensate discovery, and Tyrihans South, an oil discovery.

Tyrihans has been developed with a total of 12 wells, some multilaterally drilled, breaking down to nine producers, two gas injectors and one for injection of unprocessed water for pressure maintenance.

All of the wells are connected to five subsea templates which flow through a 43km long subsea tie back to the Kristin Platform.

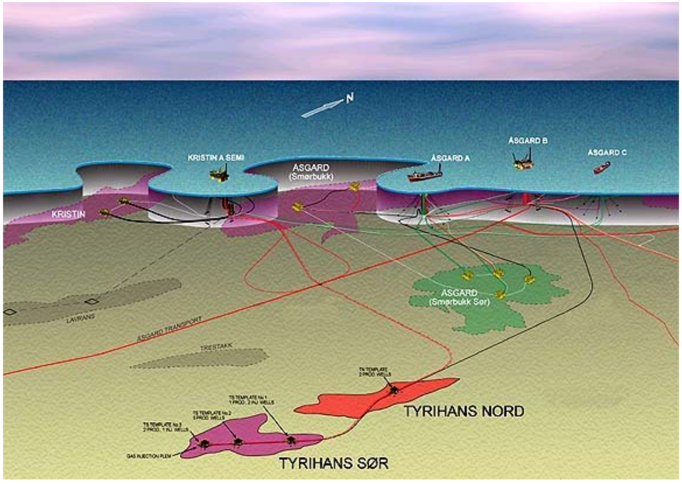

Fig 1. Tyrihans (North Sea) Oil Field

All of these wells are equipped with pressure and temperature gauges both downhole and across the well head chokes. They also all have gas lift capability to start and there are multi-phase flow meters (MPFM) installed at each well as an alternative to the high costs of well testing.

The projected production plateau for 2016 is at 15,000sm³/day and there is a contractual obligation on the produced gas which is currently constraining overall production. The allocation strategy prior to the DOF solution was completely dependent on the functioning MPFMs.

Model based field management

Production surveillance and optimisation can be achieved through the implementation of physical models which cover the entire field, from the sand face to the point of delivery (i.e. wells plus surface network models).

This allows the execution of field management activities, such as:

- Virtual metering
- Advanced well surveillance
- Well performance monitoring
  - Real-time diagnostics
  - Real time production conditions estimation (WC, GOR, Pr, PI, etc)
- Production optimisation

Fig 2. Tyrihans GAP model

In brief, the project aims to predict changes in conditions of the wells (i.e. WC, GOR etc.) so that the individual phase rates from each well can be allocated. These allocated rates can then be used further downstream for tasks such as history matching reservoir models or production optimisation to ensure that the field is being operated as required in order to meet current economic targets.

The Challenges

Model-based field management systems provide the prediction capabilities required for well allocation and rigorous optimisation (both from a production as well as a reservoir management point of view). However, ensuring that the underlying models remain valid requires orchestration of dozens of different supporting workflows and activities, whilst also involving various disciplines within the organisation.

Processes that continuously validate elements such as well models are well established in the industry. In general these processes include validations based on well tests however in the case of the Tyrihans field the wells are not tested. There is therefore a heavy dependency on the functioning MPFMs however if they fail or require re-calibration this can have serious consequences on the ability to determine the well allocation and therefore optimise production. For example, in a gas constrained oil field like the Tyrihans field, the GOR of each well is the driving factor for how the system should be optimised so without this information the asset team is very limited.

In the absence of well testing, when the MPFMs fail, there are huge problems quantifying the reservoir deliverability (IPR) which is also fundamental to any optimisation analysis. Functioning MPFMs also pose issues because without the ability to test wells it becomes difficult to interpret when the rates from a MPFM can be trusted and when it is time to re-calibrate the meters.

In this instance there is no choice but to resort to more advanced real-time validation and quality control workflows which have enough sophistication to deal with problems that have multiple solutions (i.e. when both the WC and GOR are unknown for numerous wells) which can be easily managed by the engineer.

Sustainability is also a major challenge. The scope of the system required to meet the many challenges is such that it covers virtually every discipline involved in the management of the field, from operations to well surveillance and on to field development. This requires a great level of flexibility to accommodate the needs of the various groups/users. Bespoke systems which are not easy to maintain, upscale or extend soon lose the ability to create and demonstrate continuous value. This is essential to achieve (and retain) the critical buy-in from the users.

The Solution

To address the challenges, Statoil decided to deliver all of the required functionality within a platform that needed to be easy to maintain, upgrade, upscale, and extend. From a technology point of view, the system comprises of three off-the- shelf maintained commercial product suites: Petroleum Experts' Integrated Visualisation Management (**IVM**), Integrated Field Management (**IFM**) and Integrated Production Modelling (**IPM**). This combination is referred to as Digital Oil Field (**DOF**). The use of maintained commercial products (rather than bespoke solutions) allowed the acceleration of the deployment and configuration time from years to weeks and did not require any coding.

The solution to the well allocation problem is centred around a multi-well allocation (MWA) workflow that uses a multi-variable regression algorithm to calculate the individual phase rates of the wells by combining measurements from the field and physical models (VLP, Choke, IPR or ESP). The engineer then has the ability to guide the regression algorithm through control of the:

1. Starting point which the algorithm will use.
2. The weightings associated to different models and measurements used by the algorithm.
3. The constraints that the algorithm should operate within.

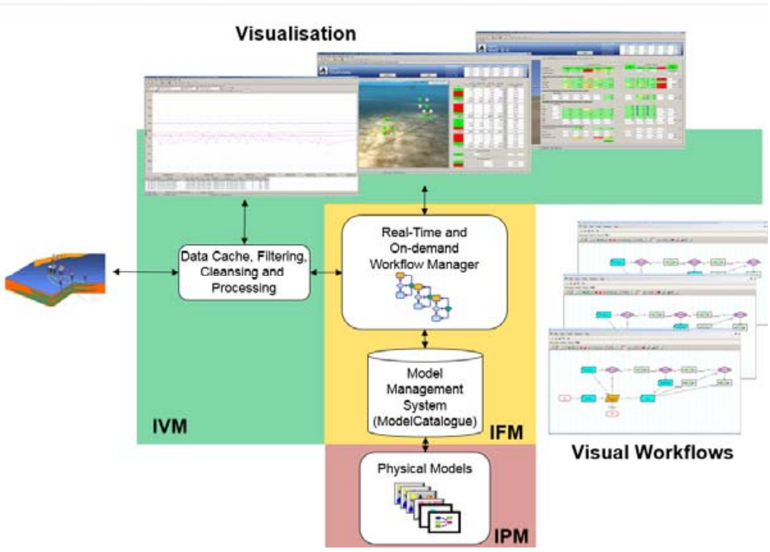

Fig 3. Simplified Digital Oil Field Architecture

This gives the engineer the capability to handle problems with multiple solutions which are inevitable throughout the course of the field life.

Deciding on the starting point, the weightings and the constraints cannot be driven by experience alone therefore it is fundamental that supporting workflows are provided to ensure that the correct direction is being followed. In addition to the MWA there are an additional seven rate calculation methods that compute the individual well rates independently. These rate signatures generated by the workflows are fundamental to the engineer for diagnosing what conditions have changed in the wellbore during the life of the field through simple redundancy checks.

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Multi Well Allocation Using Digital Oil Field (DOF) Technology In the Norwegian Sea (continued)

In addition to the multiple rate methods there are various quality checking workflows that continuously challenge the assumptions made by the engineer. These include workflows that determines the validity of the rates being measured by the MPFMs (which can potentially be fed into the MWA as either a starting point or constraints) and workflows that compute gradients and VLP/IPR intersection on the fly.

Fig 4. IVM well screen displaying a visualization of the well bore, real time data, multiple rate methods being calculated from the workflows along with the various validity checks for the different methods.

Having satisfied that a single rate method passes the many implemented sanity checks, the engineer can then select the rate as the "Preferred Rate Method" which will become the official rate for the well and the basis for calibrating the IPRs. The calibrated IPRs can be then fed into optimisation workflows further downstream that can be used to generate guidelines for managing the field so that all of the economic and commercial targets are met.

Conclusion

A top class field management system to aid the decision-making process for the Tyrihans field was delivered by the Petex **DOF** tools. The unparalleled level of integration between data, models and workflows has not only provided a robust well allocation solution for fields that cannot test wells independently, the system scope extends to handling additional activities such as reservoir surveillance and production optimisation which could not be considered previously. The use of an 'off-the-shelf' field management platform to deliver the necessary functionality allowed the solution to be deployed efficiently, while also providing the required flexibility and extensibility to accommodate future requirements.

Acknowledgments

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