

# The Digital Oilfield Are We There Yet?

**TAHA TAHA**  
Emerson Process  
Management

## A complete and integrated workflow for reservoir and production management

The last few years have seen a growing focus on the digital oilfield and a future environment where operators integrate, interpret and action real-time reservoir models and production information to optimise field operations and support production. From remote real-time facility monitoring and control through to real-time production surveillance, advanced wells and production volume management systems, we are closer to this vision than ever before.

Operators are able to evaluate the timings for tie-backs of new reservoirs, phase in or re-route wells, implement pressure boosting and artificial lift, and ensure the effective flow of hydrocarbons from reservoir to refinery – all from the comfort of their control rooms. In the field of production engineering and management, asset team members can monitor the reservoir and its complex production infrastructure of wells, flow lines and flow control devices, such as chokes, pumps/compressors and separators. By utilising measured

field data combined with optimisation software, the task of finding optimum operating conditions can be automated, avoiding trial and error procedures and increasing system throughput.

Yet, despite these developments, obstacles still remain in realising the vision of the digital oilfield, in particular in the areas of production and reservoir engineering. These two disciplines share a number of things in common. While production engineering tends to focus on the flow of fluids from the reservoir to production facilities, and reservoir engineering looks in more detail at the subsurface geologies, reservoir mechanics and drainage strategies, they still share the common goal of increasing well production rates and ultimate recovery. Yet, too often, there is lack of integration between these fields. Reservoir,

production, completions and operations engineers tend to work in different domains with different workflows and only share information when they have to.

This article argues that the digital oilfield and a future vision of integrated production management can only be solved through a closer software link between production management and reservoir engineering and a fully integrated workflow across the lifecycle of the field.

There is a need for easy-to-use, practical engineering tools, applicable throughout the life of a field, to streamline work processes, improve consistency in data use, and foster multi-disciplinary collaboration.

### Integrating Production and Reservoir Engineering

In May last year, Emerson Process Management acquired Norwegian company Yggdrasil, a provider of flow assurance and production optimisation software. Emerson is incorporating

Yggdrasil's production optimisation solution into its Roxar reservoir management software portfolio.

This acquisition is not simply a broadening of the Emerson reservoir management software portfolio. The tie-up will help integrate the disciplines of production engineering and reservoir engineering, where the daily management of oil and gas production is combined with reservoir modelling, uncertainty quantification and simulation data to help operators optimise their field development and production plans.

The new software – known as Roxar METTE – includes network optimisation, well performance, transient simulation and virtual metering capabilities as well as built-in interfaces to reservoir simulators.

### Four Main Components

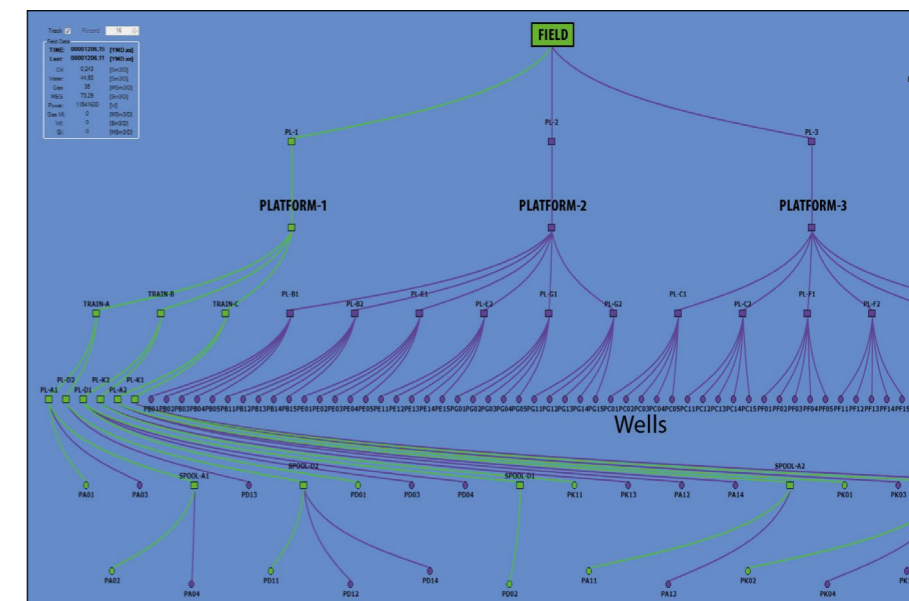
There are four key elements to an integrated production management system.

Network optimisation focuses on the surface network and enables the operator to use software to find operating points and calculate network performance data. 'What if' simulations can also be carried out.

Combining known well flow rates with a PID control module also provides the operator with a set of points for active components, such as chokes, pumps and gas lift supply, which can all be used to achieve specific production targets – subject to defined system constraints.

Well performance focuses on the capabilities of the well in delivering oil and gas – from which profile data, gas lift hydraulic analysis, and vertical flow performance tables can be created. Components, such as compressors, pumps and choke valves, can be modelled. In addition, well or flow lines capacities can be analysed using multiple boundaries and can quantify the effect on production potential.

Transient analysis is used for the time-dependent simulation of well and flow line behaviour. Typical applications where the transient module in the Roxar METTE software can be deployed include cool-down times for different pipe wall insulation configurations, the calculation of the necessary hydrate inhibitor amounts during cold start-ups, and the evaluation of requested times



*Network simulation: the production management software has a demonstrated capability for handling large and complex networks, either coupled online to one or more reservoir simulators or by using tank type models for well inlet boundary conditions. In this illustration, the purple line represents non flowing/non producing and the green line represents flowing/producing.*

for flow line depressurisation.

Virtual metering provides a cost-effective solution for finding well phase flows, requiring only the connection of a computer to a production database for the retrieval and measurement of field data. Operators can measure and interpret field sensor measurements and calculate flow based on virtual measurements coming from, for example, temperature and pressure probes.

### Bridging the Gap

The strong links with reservoir simulation and history-matching is where the production management software plays the most significant role in bridging the gap between production and reservoir engineering. This can be seen in the software's focus on network simulation. This module is an advanced engineering tool for single and multiphase flow systems. It relies on a very fast and robust algorithm with demonstrated capabilities that have been in extensive use on the Ormen Lange field development offshore Norway and for planning on the Shtokman field in the Russian part of the Barents Sea.

By directly connecting to reservoir simulators, the software provides concept-dependent production profiles, with reservoir out-takes reflecting production targets and constraints in the downstream production network.

This coupled capability from the subsurface allows for the seamless simulation of hydrocarbon flow through the reservoir production system to a processing facility. This provides life-of-field (LOF) variations in mass and energy balances and optimised power and gas lift use as well as hydrate inhibitor usage. It determines well routing, the effect of pigging and scheduling for infill wells or third party tie-backs, the quantification of the effect of pressure boosting equipment and timing, and the quantification of the effect of subsea separation.

Well inlet boundary conditions in the network are generated by the reservoir simulator, providing phase ratios and flowing bottom hole pressures in the form of IPR tables.

A large number of additional network production targets and constraints can also be specified, the implementation of which are executed during run time and dictated by user-specified conditions. The constrained problem is also solved through employing active components, such as chokes, gas lift, pumps, compressors and heat exchangers. With no or limited active components, solutions will be dictated by well flow potentials.

The software's calculation speed is high and scales linearly. Depending on field complexity, LOF simulation times are typically measured in minutes. Using

*The production management software was used for planning on the Shtokman field.*



## Technology Explained

tank type models (decline curves), multi-case production profiles can be made very quickly, providing a useful tool for quantifying system parameter changes.

When coupled to a reservoir simulator, the software feeds back guide rates to the reservoir for the next time step, reflecting current production system capacity. The production network can be interfaced to service networks for lift gas and/or continuous hydrate inhibitor distribution, with all networks being solved in each time step. Constraints in the service network(s) will be reflected in the production network.

The different available options for production optimisation make this a powerful tool for investigating different production strategies to see the effect of recovery.

The software currently supports interfacing to many reservoir simulators but will become more closely aligned with Emerson's Tempest MORE as a result of the acquisition.

### Other Reservoir Engineering Links

There are other ways in which the new software links in with reservoir engineering tools. Virtual metering results, for example, can be used with reservoir model history-matching as well as for daily or historical production allocation. The combined virtual metering and forecasting capabilities add up to a powerful production management tool, in particular when combined with PID control functionality.

With the close integration of the software with Emerson's reservoir engineering solutions – its simulation tool Tempest MORE and history-matching and sensitivity tool Tempest ENABLE – an effective system is available for production forecasting and optimisation. With Tempest ENABLE's ability to intelligently drive the simulator through hundreds of realisations and conduct 'what if' scenarios on a wide range of reservoir scenarios, the same will be the case when combined with new software, where the tools can work together to provide a wide range of values and look at a large number of scenarios.

### Two North Sea Fields

Examples of integrated production management can be found in two North Sea fields.

In the first case, the software is being used as a flow assurance tool on a medium size oilfield in the North Sea with three different reservoirs requiring artificial lift in the form of gas lift. A large number of development alternatives were screened in the early phase to create concept-dependent production profiles.

To provide consistent LOF data, the software was used to perform coupled simulations, interfacing the three separate reservoir simulation models with gas lift optimisation. The production network model was simultaneously interfaced with a gas lift supply network to determine its variation in mass and energy balances. Using decline curves that originated from these simulations, the effects parameter variations, such as flow line and tubing sizes, were investigated to find optimum sizes based on reservoir model predictions over field life. Lifetime mass and energy balances for the production system were generated for different development concepts including the use of multiphase pumping. Using the transient module, cooldown and heat-up simulations were performed to address insulation requirements. Blowdown simulations were also performed to address both time and liquid drain volume requirements.

The second application is in a marginal

North Sea oilfield with a heavy non-Newtonian fluid that required artificial lifting. In this case, the software provided functionality for the use of shear-dependent viscosity data during both steady state and transient simulations.

Decline curve data from the reservoir simulation model was used as input to a production network model. The network model was then used to predict artificial lift times, together with system lifetime mass and energy balances. These used two alternative lift methods in the form of electrical submersible pumps and gas lift. The strong gelling tendencies of the production fluid also required the implementation of experimental yield stress data to perform realistic transient start-up simulations of the wells and flow lines. The development concept also included SWAG (Simultaneously Water Alternating Gas) for gas reinjection into the reservoir, simulated by the use of the software.

### A New Era

Operators today are looking for a workflow that integrates production and reservoir engineering and is part of a truly digitally enabled oilfield. Combining data from predictive reservoir models, production modelling and field instrumentation will enable operators to monitor production continuously and use information from the field when forecasting future reservoir performance and making operational decisions. ■

*Effect of gas lift on oil production potential for different mandrel setting depths. Oil potential increases with setting depth and has a maximum at given rates of lift gas, increasing with setting depth.*

