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Abstract

Gas Field Planning Tool (GFPT) was developed in 1990 by the Shell Group of Companies to fill the need for a tool for gas field planning and development using deterministic subsurface and surface models. Main initiators were Shell Canada, NAM (the Netherlands), Shell Expro (UK) and BSP (Shell Brunei), as these companies are major gas producers.

Shell Companies now have several years experience with using the GFPT. Application ranges from simple single field models to corporate-level models with a large number of gas reservoirs and wells. Shell companies now using GFPT models are Shell Expro (UK), BSP (Brunei), SSB (Malaysia), Shell Canada, SPDC (Nigeria), SDA (Australia), Woodside (Australia), PDO (Oman), NAM (the Netherlands), New Business Development (e.g. Lunar Project) and in future also Shell Egypt.

NAM currently has a GFPT model for the Anjum field in Friesland and for the Ten Arlo field in the north of Holland.

GFPT is currently being migrated to an HFPT (Hydrocarbon Field Planning Tool), which can also be used for planning of condensate, oil and water developments and for control of hydrocarbon compositions in the network using PVT de-lumping at the well head (e.g. for LNG plants) and optimisation techniques (linear, non-linear or based on bean-back lists).

Keywords: software, multiple fields, gas field planning tool, Anjum Field

Introduction

The Gas Field Planning Tool (GFPT) was developed in 1990 by the Shell Group of Companies to meet the need for a tool for gas field planning and development using deterministic subsurface and surface models (Edens et al, 1996). Main initiators were Shell Canada, NAM (the Netherlands), Shell Expro (UK) and BSP (Shell Brunei), as these companies were major gas producers of Shell at that time.

GFPT models the interaction between the subsurface gas reservoirs and the surface facilities, and predicts the overall performance of gas and gas/condensate production systems from the reservoir to the sales point in the medium to long term (6 months to 30 years). This is important for multiple gas fields using shared surface facilities. Depending on the level of detail required and the nature of the problem, reservoirs, surface facilities and planning/development can be modeled to various degrees of complexity, from very simple to very complex.

Modules

Subsurface

For complex reservoirs Shell's in-house reservoir simulator MoReS is used and for simple reservoirs Shell's Tank. MoReS is a rigorous reservoir simulator using various PVT models including compositional models, and it can also handle fractured reservoirs. Tank uses a material balance model, inflow performance relations based on A and F factors and has a well model based on lift tables or string tables.

Surface

For surface network modeling GFPT now uses SurfNet and in the future PTNet, an interface to PipePhase, a surface simulator from Simulation Sciences, which calculates pressure drops and handles various PVT models (e.g. gas, condensate, black oil and compositional). Models can be set up in any detail using various types of surface equipment, including compressors, chokes, DPDT tables, heaters, coolers, regulators and separators. Pressure drops in a gathering network can also be calculated by specifying pressure-drop formulas in the input.

Integration/planning/development

DevPlan handles integration of the subsurface and surface modules, planning (contracts) and development.

Volume, heating value, forecast, injection and fuel gas contracts can be specified, which can have a profile, load factor, and off take rate. Both deliverability and offtake for each contract are reported. Parameters such as H_2S, CO_2 and N_2 content and GHV are controlled at delivery points. Development options can be activated from user-specified lists of any event (for instance, when a gas contract falls short) and these events can also be specified based on time.

Volume constraints for wells and pipelines in the network can be specified, that override the subsurface and surface constraints. Uptime factors of wells and clusters model the down-times.

Volume cutbacks, when deliver ability is larger than required offtake, are done using well bean-back lists or linear optimization using the simplex method.

Coupling between the subsurface and surface simulator is either at the individual well or at the cluster level. For large models with over 100 wells, coupling at cluster level and ignoring the pressure drop between the well and cluster, greatly improves the stability and CPU efficiency. Checking the contribution of each well to a contract or delivery point can be done using the density and GHV of gas at the well or the delivery point, respectively.

Other features

The system can handle multiple MoReS and Tank reservoirs and multiple surface networks. These are coupled in a loose way by the planning/development module DevPlan. Based on decline of wells and honouring recurrent (time-based) data, a maximum time-step-size is determined and each of the simulators steps to the next point in time independently. This mechanism is very efficient in CPU usage.

The GUI allows the users to define multiple restart points, define steps in time interactively while monitoring the performance of the model viewing graphs and reservoir plots, to stop at any time and to go back to certain restart points. This fully interactive flexibility allows for e.g. rapid screening of sensitivities or multiple runs from a restart point.

Time monitors are used to trigger any type of recurrent data. Time step monitors are used to define conditional relations, which are checked at the start or end of every time step based on a user-defined priority for each time step.

The Input Language of the system is very powerful and can be used e.g. to define new functionality and controls. iMath, a Mathematical Toolbox similar to Mathematica but integrated with GFPT, is also available for creating generalized tools. Combined with the unlimited access of input and output data at any time during the simulation, the Input Language and iMath allows the users to define any missing functionality.

Models can be built using the GUI or the batch Input Language, but the entire model definition including plot files, events or new functionality can always be saved in ASCII format input files, which is important for large and complex models. Once a model has been built, runs can be done interactively or in batch using the ASCII format input files producing e.g. PostScript plots and output tables using predefined plot and table definitions. Through the use of locally stored include files, a team can work on a centrally stored main model, but apply individual changes without affecting the main model.

iMath tools supports Multiple scenario runs, e.g. for sensitivity studies using splicing of critical parameters.

Experience

Shell Companies now have 8 years experience in using GFPT and have constructed various models, from simple single field models to corporate level models with a large number of gas reservoirs and wells. Shell companies now using GFPT models are Shell Expro (UK), BSP (Brunei), SSB (Malaysia), Shell Canada, SPDC (Nigeria), SDA (Australia), Woodside (Australia), PDO (Oman), NAM (the Netherlands), New Business Development (e.g. Lunar Project) and in the future also Shell Egypt. Examples of such models are Sole Pit and LeMan from Shell Expro (Deutman and Hollman, 1996; Deutman and van Rijen, 1997), Ten Arlo and Anjum from NAM and corporate models that model the entire gas business of a Shell OU e.g. BSP and SSB.

Key factors for success were a flexible (well or cluster level), intelligent coupling of the subsurface and surface models and providing sufficient parameters to tune the coupling, stabilizing convergence and improvement of CPU performance.

Other key factors for success were support from Reservoir Engineers of Shell Research and Technical Services in building the large corporate models, sharing best practise in modelling and quick response in correcting limitations and errors in the tool. Tailoring of the GFPT tool to specific business needs proved to be essential for successful deployment.

Currently, the tool is used by an integrated team of reservoir engineers, surface engineers and planners/developers but still has an emphasis on reservoir engineering. Engineers develop discipline specific models in isolation and the planners/developers merge subsurface, surface and planning/development models.

Economics is currently done in a post-processing mode, after each scenario has been run to provide output tables. Simple (time-step based) economics to identify the most favorable development can be done using iMath during a simulation such as activating a new well or installing a compressor based on lowest Capex and Opex per additional volume of gas.

Future

GFPT is currently being migrated to an HFPT (Hydro-carbon Field Planning Tool) which can also be used for planning condensate, oil and water developments and to control hydrocarbon compositions in the network using PVT de-lumping at the well head (e.g. for LNG plants) and optimization techniques (linear, non-linear or based on bean-back lists). Prototypes of such models have already been built using iMath and MoReS for Woodside (Australia) (Kuyper et al, 1997) and Shell Expro.

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