Petex

GAP

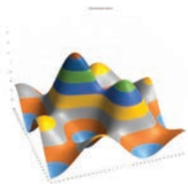
MULTIPHASE NETWORK MODELLING AND OPTIMISATION

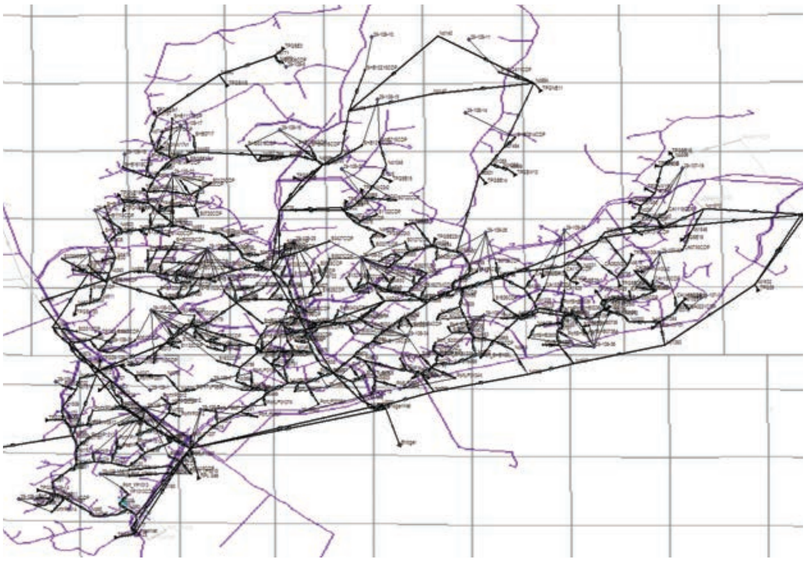
INTEGRATED PRODUCTION AND INJECTION NETWORKS

EQUATIONS BASED SOLVER

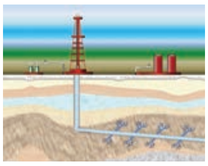
$$\begin{bmatrix} a_{1,1} & a_{1,2} & a_{1,3} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & a_{2,3} & \cdots & a_{2,n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{m,1} & a_{m,2} & a_{m,3} & \cdots & a_{m,n} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix}$$

NON-LINEAR OPTIMISATION



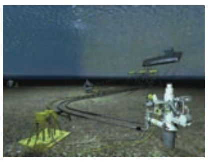


UNCONVENTIONALS

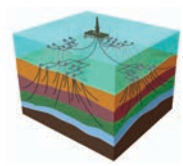


RULE BASED CONSTRAINTS

FLOW ASSURANCE

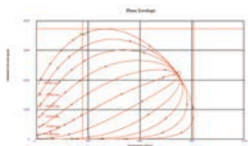


WELL PERFORMANCE



SURFACE EQUIPMENT MODELLING

ADVANCED PVT HANDLING



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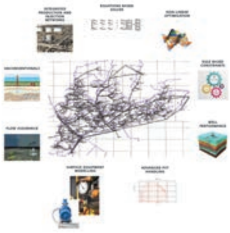


GAP

MULTIPHASE NETWORK MODELLING AND OPTIMISATION

INTEGRATED PRODUCTION AND INJECTION NETWORKS

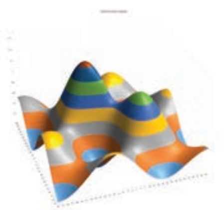
Petex was created in 1990 with the objective of providing best in class software that would allow various disciplines to perform studies in understanding the behaviour of fields as well as design systems and optimise production. GAP was designed to eliminate artificial boundary conditions in reservoir, well and surface network models, through the creation of integrated models using Petex tools. It is able to consider the multiphase network response of multiple wells (with different PVT) producing into a common production system, where the response of one well would affect production of another (i.e. back pressure response). Today GAP is the ***most sophisticated steady state multiphase network optimiser*** that exists in the industry, with many **proprietary features** that allow engineers to maximise production from oil and gas fields all over the world. GAP has been the tool of choice for over 420 oil companies in over 80 countries and the corporate standard for all of the super majors in the area of integrated modelling. Year on year new features are added and improvements are made based on the development strategy of Petex and the requests from clients presented at the user meeting.

EQUATIONS BASED SOLVER

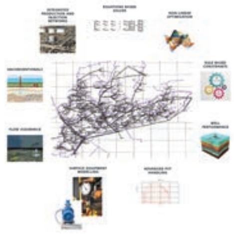
$$\begin{vmatrix} a_{1,1} & a_{1,2} & a_{1,3} \\ a_{2,1} & a_{2,2} & a_{2,3} \\ \cdots & \cdots & \cdots \\ a_{m,1} & a_{m,2} & a_{m,3} \end{vmatrix}$$

The objective of GAP is to capture the full field response of a hydrocarbon field using physical descriptions of each item that will affect production. The fundamental calculations done in GAP relate to balancing pressure, flow and temperature from all items in a system based on a single boundary condition at the end point (for production networks) or starting point (for injection networks). The solver being used is an ***equation-based proprietary engine*** that has been specifically designed and built for solving integrated oilfield networks. Starting points are internally evaluated and decades of research have allowed this to be the **fastest network solver** in the industry today (independently verified in tests by various oil companies). The solver takes into account all the physics that are present in the system and works by drawing information from all parts of the system, by performing dynamic calculations on the physical models (for pipelines, chokes, wells, compressors etc), or by using pre-calculated responses (for example lift curves).

NON-LINEAR OPTIMISATION



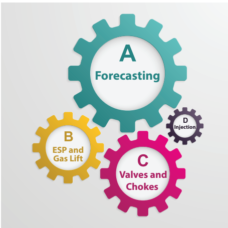
Once physical models are in place as an integrated system, optimisation algorithms can be used with the objective of increasing hydrocarbon recovery. For the past 20 years, one of the biggest areas of research in Petex has been on a mathematically rigorous ***global non-linear optimisation algorithm that is proprietary and unique in the industry***. The user does not have to provide starting points and intelligence built into the system allows for selecting the appropriate technique depending on the problem at hand. Local optimisation techniques like BFGS, Fletcher Reeves, Rank1 and various others are nested within the structure of the optimiser and are coupled with a proprietary global optimum search engine that searches the whole production and injection space for the best possible solution. The control settings that will satisfy constraints as well as maximise production are then presented to the user in the form of choke settings, artificial lift quantities, compressor speed and any other control that may exist in the field and has been allowed to be considered in the optimisation problem.



GAP

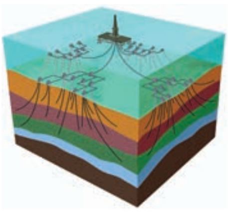
MULTIPHASE NETWORK MODELLING AND OPTIMISATION

RULE BASED CONSTRAINTS



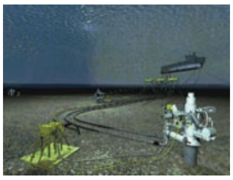
GAP is often used for **long term planning activities** and for testing various **strategies** through long term forecasting. The objective in this context is not to optimise production on a day to day basis, but rather to honour constraints and evaluate long term production goals. This is achieved by using the **Rule Based Network Solver** functionality. The model is setup in the same way as it is to achieve optimisation objectives, the difference being in the fact that the constraints are met through a set of well defined rules that are adjusted by the user depending on the problem at hand. As this algorithm is extremely fast, forecasts can be obtained quickly and can include artificial lift individual well production maximisation (equal slope techniques for gas lifted wells for example).

WELL PERFORMANCE



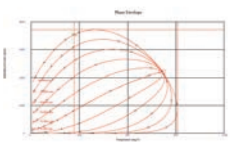
The performance of wells is typically handled by embedding PROSPER models in the integrated system, although dynamic well models can be captured through native GAP calculations. Wells can therefore be **evaluated and optimised** over time with respect to the back pressure response of the entire network. Design and performance can be assessed through the life span of each well, considering artificial lift (pumps, gas lift, etc.) or any other type of intervention. **Flow assurance** analysis features very strongly in well modelling, with dynamic calculations as well extended lift curves being used to assess the safe flowing envelopes that pressures, temperatures and rates will allow. Diagnostics of any proposed/existing design and how it handles future production conditions are at the centre of evaluation workflows in the tool.

FLOW ASSURANCE



Flow assurance studies centre around the **detection** of specific phenomena that are a function of the **fluid PVT** or the **pipeline hydraulics** (e.g. **Slugging, Liquid loading, Wax** formation, **Hydrate** formation, etc.). GAP harnesses all the existing functionality from PVTp and PROSPER to detect these phenomena across the entire surface network, and provide information that will address flow assurance challenges over time. Moreover, workflows can be setup in RESOLVE so that all the native functionality in GAP can be used as part of a bigger solution formulation scheme, going as far as performing calculations in real time for any objective the client wishes to embed in support of their field management activities.

ADVANCED PVT HANDLING



GAP has been designed to be able to handle different PVT descriptions that are used in the reservoir, wells and surface network. For instance, a fully compositional reservoir simulator will typically contain no more than 6-8 components, and everything downstream of this will usually contain more. GAP can use the **lumped** composition, and perform the **delumping** to a larger component composition. The Black Oil to Compositional feature in GAP was created to enhance the performance of these integrated models. This was achieved by using the EOS to generate the inputs of Black oil model, and using both descriptions in tandem. The consequence is a fluid description that harnesses all the advantages of EOS and black oil descriptions, without any of the weaknesses.

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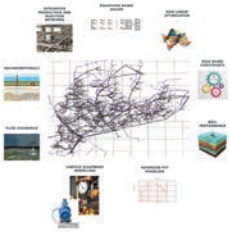
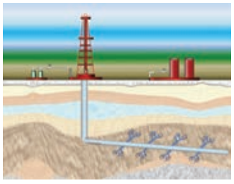


GAP

MULTIPHASE NETWORK MODELLING AND OPTIMISATION

UNCONVENTIONALS



GAP is often used for **long term recovery estimates** and testing the intended field. In recent years the production of unconventional reservoirs has become more viable and as such the need to capture the inflows, system response and PVT of **coal bed methane** (CBM), **tight, shale** and **heavy oil** reservoirs has increased. GAP has extended its functionality into this domain, allow the dewatering cycles and production cycles of CBM to be captured. The tight reservoir and shale inflow response is captured in REVEAL, but the multiphase flow in the well, and surface network is analysed in GAP.

SURFACE EQUIPMENT MODELLING

As exploration focuses on more remote inaccessible locations, long trunklines to transport fluids back to processing facilities are common place as are the use of various **turbo-machinery** to supplement the production efforts. In GAP **compressors** (single and **tandem screw compressors, reciprocating** and **multiphase**) and pumps (**performance curves, jet pumps** and **bespoke multiphase**) can all be modelled. Their response in time as production conditions change can also be assessed, thus making GAP an invaluable design tool in this context.

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