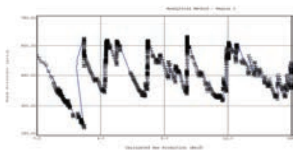
Petex

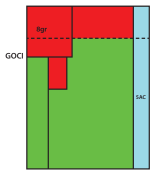
MBAL

ANALYTICAL RESERVOIR ENGINEERING TOOLKIT

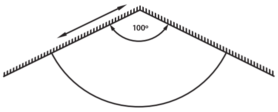
HISTORY MATCHING



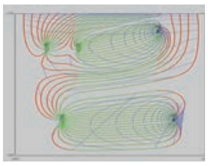
MATERIAL BALANCE

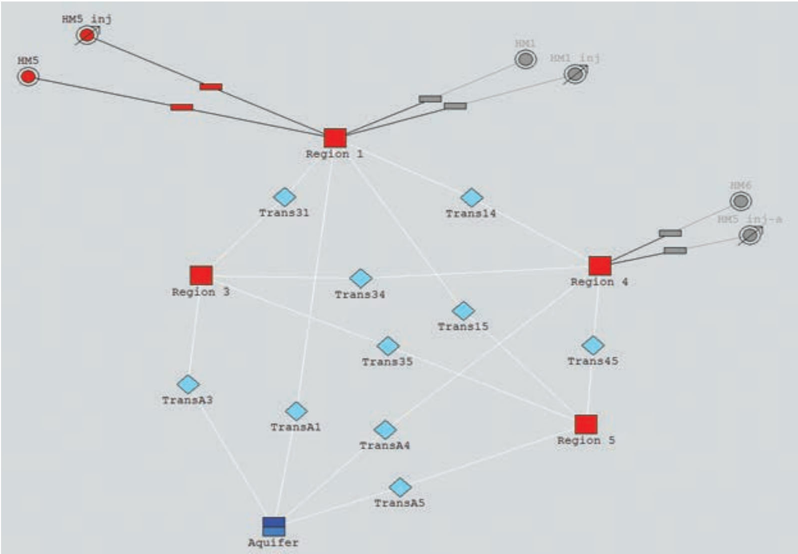


AQUIFER MODELLING

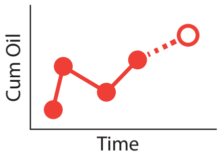


STREAMLINES

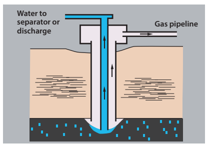




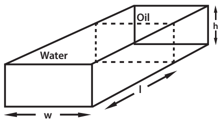
FORECASTS



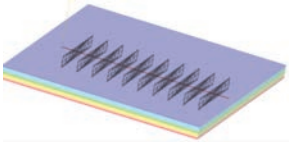
COAL BED METHANE



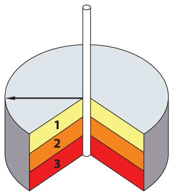
1D MODEL



TIGHT RESERVOIRS



MULTILAYER PRODUCTION



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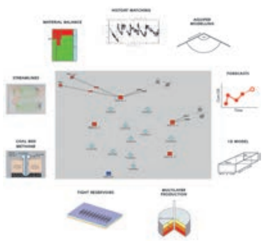


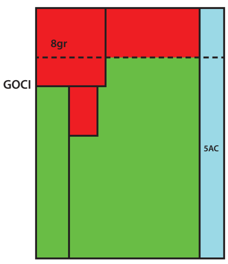
MBAL

ANALYTICAL RESERVOIR ENGINEERING TOOLKIT

MBAL

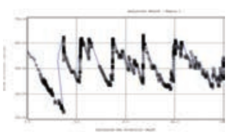
MBAL- commercialised in the early 1990s- is a reservoir engineering tool kit that is intended to assist reservoir engineers in their analytical studies of the reservoir. This includes, but is not limited to, material balance calculations. Aside from **Material Balance**, other tools also available are **Decline Curve Analysis, 1D model, Monte Carlo Simulations, Coal Bed Methane, Reservoir Allocation, Tight Reservoir Modelling** and **Streamlines**. All available techniques can be used in isolation or in combination to achieve engineering objectives. As the name of the program suggests, Material Balance calculations are a core functionality and includes many advancements on the classical Material Balance concept found in literature. Aside from allowing engineers to estimate the oil or gas originally in place and understanding ***drive mechanisms***, many novel approaches such as performing predictions using relative permeability curves and multi-tank modelling ensure that MBAL can provide a solid platform on which reservoir physics and production plans can be studied in detail.

MATERIAL BALANCE



MBAL allows non dimensional reservoir analysis to be conducted throughout the life of the field, whether this is in early field life when limited data is available, or even in mature fields where more certainty exists. As such, this straightforward but powerful reservoir toolkit can be applied throughout the life of the reservoir, and is often used in conjunction with numerical simulators as a quality check of history matching, and/or as a proxy model for fast calculations. Using limited data (PVT and cumulative production) the engineer is well equipped to find the amount of oil in place, and any associated drive mechanisms. Unlike the classical theory, MBAL can be used to describe any hydrocarbon fluid (Oil, Gas or condensate) using either Black oil or compositional descriptions in scenarios where variations in PVT with depth occur (Compositional gradient are important in high relief reservoirs). Moreover, compartmentalised reservoirs with partially sealing faults, or pressure activated faults can be modelled and history matched by creating multi-tank models with transmissibilities. This evolution of the material balance concept is another innovation from Petroleum Experts, and extends the range of applicability to full field life.

HISTORY MATCHING



MBAL's progressive menu options lead the engineer logically through the history matching process, which is performed graphically using industry standard techniques (e.g. **Cole, Campbell, P/Z plots**) and allows the identification of drive mechanisms in place, and whether the measured data entered is to be trusted. Having used the analytical methods available in MBAL to history match the analytical model, a simulation is run of the history, and yields two valuable results: Firstly, by running the historical period in a simulation, the user can compare the production profiles predicted from the model and the data entered (a close match indicating a good history match). Secondly, by running the history as a prediction, MBAL will calculate all the historical production profiles, saturations and reservoir pressures in the historical period. This can be used to create custom relative permeability curves and **calibrate** these to the History matched model. The historical data can be entered on a tank basis, or in a well by well basis, in the latter context the Relative Permeability curves can be generated for the draining area of each well using the approach described above. It is this innovative capability that allows the analytical model to approach the response of reality and is a departure from classical literature based models.

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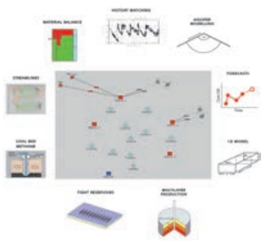
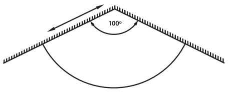


MBAL

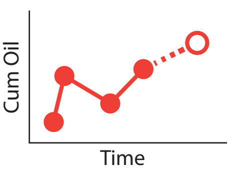
ANALYTICAL RESERVOIR ENGINEERING TOOLKIT

AQUIFER MODELLING



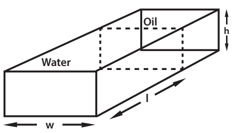
For existing reservoirs where the PVT and historical production is known, MBAL provides extensive matching facilities and the ability to model the **size** and **strength** of **drive mechanisms**. Both **steady state** and **transient responses** can be modelled in MBAL, using the industry standard and Petroleum Experts Modified models. The sizing of the aquifer (based upon its pressure support response) provides a way of calibrating known physics against production data, which once calibrated can be used to forecast.

FORECASTS



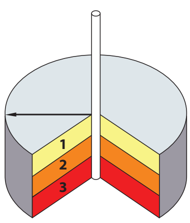
MBAL can be used to carry out forecasting/predictions in two ways, (i) as a reservoir tool in an integrated model or (ii) as a standalone reservoir analysis tool kit. In both cases MBAL can perform **fast calculations** honouring the history matched **aquifer** and **relative permeability's** as the basis for predictions. Using the history matched model **relative permeability curves** are generated. These curves -which are physically representative - describe how one phase flows relative to the others in the well drainage area. Implicit to these curves is **well positioning** in the reservoir, and allows **two wells in a single homogenous tank** to exhibit different production profiles (e.g. if one well is closer to the **Oil-Water Contact** its production history will give different Relative Permeability curves). The creation of bespoke relative permeability curves for each well based upon historical production, is **novel** and a departure from classical theory. Combined with **GAP**, full field development planning is possible. When run standalone, MBAL can be used to analyse the saturations and pressure decline over time. Using a **multi-tank** system with **transmissibilities** can be used to model **partially sealing faults** and **pressure activated faults** where production from one compartment (**compartmentalised reservoirs**) initiates flow from one part of the reservoir to another as production occurs in the forecast.

1D MODEL



The **1D Model** allows the study of the displacement of oil by water using fractional flow and Buckley Leverett equations for a single layer. In the Multi layer context, the **Multi-Layer tool** allows the creation of a set of Relative Permeability curves for each layer using the immiscible placement theories of **Buckley Leverett, Stiles, Communicating Layers** (using theory from **L.P Dake**) and simple (single cell simulation). Having generated the profiles, these can then be seamlessly brought to the material balance tool for further matching and analysis.

Multilayer Production



Often wells can be completed in multiple layers, and production from several producing intervals can be achieved in the field. In this context it is customary to measure the production rates at the surface rather than on a layer by layer basis, and the classical method of allocating production was on the basis of permeability and pay height. The **Reservoir Allocation tool** is a novel modification to this allocation method, and uses IPRs to perform this back allocation. Once allocated the rates can then be brought from the **Reservoir allocation tool**, to the **Material Balance** tool, and a history match performed as usual. This can be performed iteratively until a history match is achieved. Alongside the multi layer systems, **multi-tank** systems, **gas recycling, inter-tank transmissibility's** can all be captured in MBAL.

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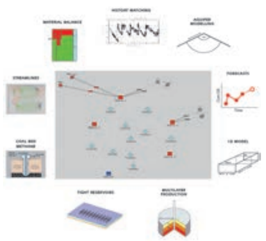
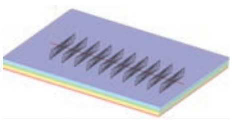


MBAL

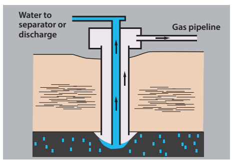
ANALYTICAL RESERVOIR ENGINEERING TOOLKIT

TIGHT RESERVOIRS



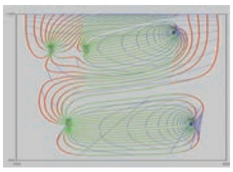
Steady state IPRs assume that the reservoir boundary "feels" the production in a negligible amount of time. In **tight reservoir** plays this assumption breaks down as these conditions are reached in the time span of decades rather than days: as such it has been conventional to use **type curves** (from Pressure transient analysis) to try and predict the gas in place. MBAL has **Blasinghame** and **Agarwal-Gardener** type curves that allows the engineers to find GIIP, however these types curves have a geometry implicit within their formulation. These type curves have been implemented in MBAL for some time now, allowing MBAL to generate unconventional IPR responses, that can later be used for predictions and forecasting. These have been essentially superseded by the novel P_DT_D approach in RESOLVE, but are still used as a cursory quality check of production data prior to performing the analysis in RESOLVE.

COAL BED METHANE



There are no real limitations (besides the fundamental material balance assumptions) on which fluid or reservoir types that can be modelled: **Oil, gas, tight gas, condensate, Coal Bed Methane** (using the **Langmuir Isotherm**), **multi tank systems** can all be modelled. In the **Coal Bed Methane** context MBAL can be used to model the release of methane gas from the coal bed using either the **Langmuir** or modified **Langmuir isotherms**. Using these isotherms, predictions of the **dewatering** phase and **production** phases can be captured and integrated with the well and surface network response.

STREAMLINES



One of the investigations reservoir engineers typically perform relates to the determination of breakthrough time and evolution of watercuts (especially important in water flooded reservoirs). Material balance can be used to perform these forecasts, but necessitate production history data, which is not always available: this is where the **streamlines** functionality comes in. The streamlines module in MBAL allows a quick 2-dimensional simulation to estimate (I)**Sweep efficiencies** and (II) producing well **fractional flows** for a set well pattern of producers and injectors. This is not intended to replace the reservoir, rather allow a quick analysis of different well patterns and the overall effect on recovery. This 2D streamline tool allows the engineer to understand how the flood path of an injection well supports the producing well, determining **water breakthrough time** and **evolution of watercuts** (especially important in water flooded reservoirs). The streamlines tool is to be used when the Material balance and numerical simulation approaches are not adequate (i.e. MBAL will need history, and numerical simulations are computationally expensive when considering multiple producer injector patterns) and a fast way of finding breakthrough and watercut profiles is required.

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