The Gas Storage Optimization Program

GASTOP is a development of MARACO, Incorporated

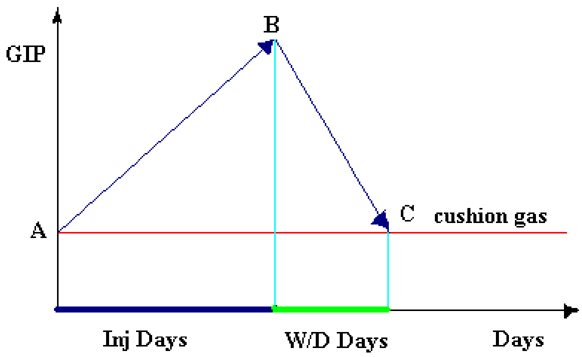
The team from Maraco, Inc. is proud to announce the release of GasTop, their new gas storage design program. GasTop is a Windows based software application that helps determine the optimal economic design model of gas storage facilities. The model presently used in GASTOP corresponds closely to the way that a gas storage operator in California prices its service. In designing a storage facility engineers try to find the optimal economic balance of three required constituent elements:

1. *amount of cushion gas for the reservoir, or each reservoir, hosting the facility,*
2. *number of wells in the reservoir, which in turn determines the number of wells to be drilled, and*
3. *total compressor HP, and the optimal location(s) thereof.*

Using a gas reservoir simulator, an engineer can manually test different combinations of these elements and select the combination that gives the best result. GASTOP automates this selection process.

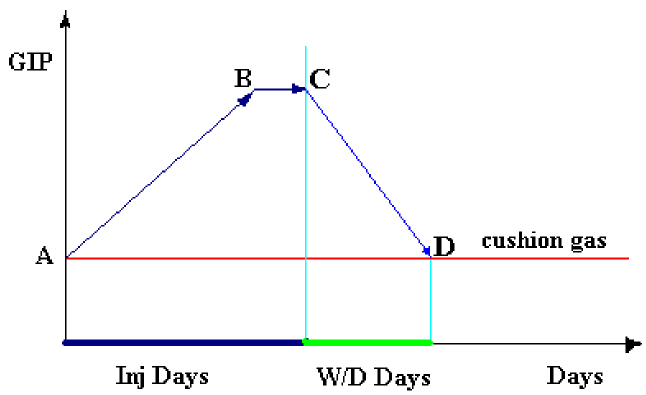
Defining A Gas Storage Cycle

A gas storage cycle (displayed in the drawing to the right) in GASTOP consists of one injection period (segment A→B), followed by a withdrawal period (segment B→C). Gas In Place (GIP) at the beginning of a cycle (point A) must be the same as at the end of the cycle (point C).



The time span of the injection phase is fixed, though the injection process can (and must) stop earlier if the pressure in the reservoir reaches the maximum allowed value or the injection rate falls below a prescribed cutoff rate.

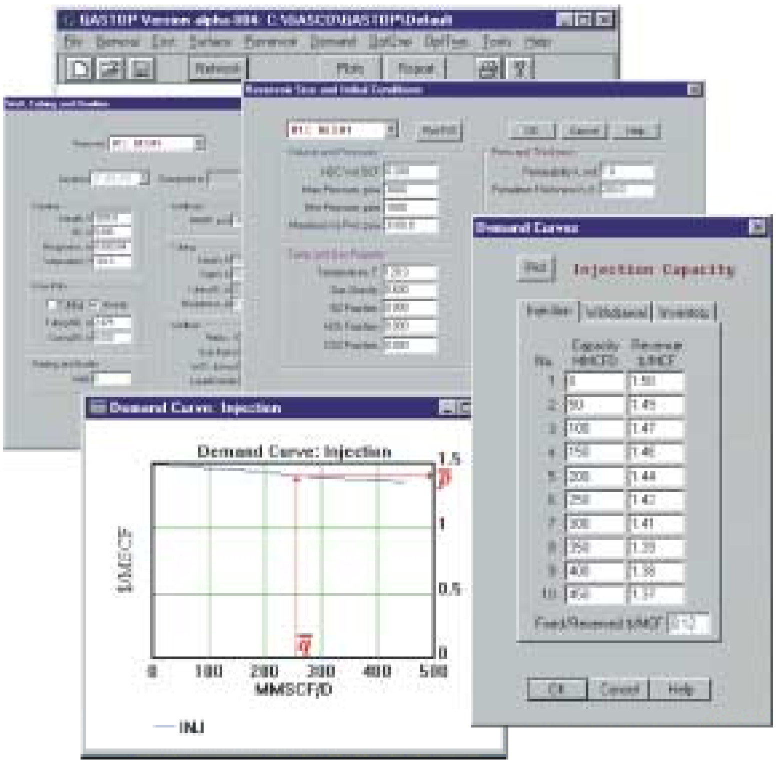
In the drawing below, gas is injected during time segment A→B causing GIP to increase steadily. Injection is stopped at B so during time segment B→C GIP remains constant. In GASTOP, withdrawal of gas from the reservoir stops if one of three conditions occurs:



1. *time span of the withdrawal phase reaches the maximum allowed,*
2. *withdrawal rate falls below a prescribed cutoff rate, or*
3. *GIP falls to the prescribed cushion gas volume*

If the withdrawal phase of a cycle stops because of conditions 1 or 2, and GIP is greater than the prescribed cushion gas volume, the cycle is considered invalid. In GasTop, a gas storage facility may contain up to 5 reservoirs, which require the following variables for each reservoir; *(a)* *amount of cushion gas for the reservoir(s) hosting the facility, (b) number of wells in the reservoir, which determines the number of wells to be dilled, and (c) amount of 1st & 2nd stage horsepower for up to 5 compressors in the surface network.* To allow rapid screening of the potentially large number of variables, a simplistic tank-type reservoir model is used to determine gas flow rates for a selected set of variables in a design case. These rates are combined with the revenue functions to make a full economic evaluation of the case. The results of which include; *investments in wells & compressors, make-up cushion gas and surface processing equipment, and operating costs of all equipment and activities.*

A sequence of increasingly sophisticated search methods is used to find the variable set that maximizes NPV. The revenue function used in GASTOP corresponds closely to the way US based gas storage operators price their services. The revenue stream is derived from charges for three services, which are: *storage capacity, injection capacity and production capacity.* GasTop also allows sensitivity studies (incremental economic evaluation runs) for key variables and parameters.



The GasTop Interface

GasTop has been designed with a relatively short learning curve and an interactive Help system that guides the user through some of the more complicated aspects of the program. Easy-to use screens are associated to all functionality, plus all input sections have graphical plots that appear at the click of a button.

GASTOP currently operates as a stand-alone application, but plans are underway to interface it directly to the GMAN simulator and, other industry standard simulators. This first commercial release has been designed for simplistic modeling of the reservoirs and an upgraded version is currently in development, which will handle much more complex field and reservoir configurations. Additionally, changes are also underway to include a standardized European economic model.

For GMAN Users

As a complement to GasTop, **GMAN** has been modified to allow simulations to be made using daily time steps (a run is one year or less). Using restart files, a sequence of annual cycles can be simulated to determine steady state conditions. GMAN.HST provides graphs of pressure and flow rate vs time for all significant locations in the reservoir/flowline model.

New Feature!

GASTOP's Oil Material Balance Equation (MBE)

Knowing the hydrocarbon pore volume (HCPV) correctly is an essential requirement to properly design and engineer the conversion of a depleted oil reservoir into a gas storage reservoir. Verification of the accuracy of any value of HCPV obtained from the reservoir files is almost certainly lacking. The literature gives many examples of highly erroneous volumetric estimates of HCPV caused by errors in core measurements – porosity, connate water saturation, rock compressibility. The accuracy of performance estimates of HCPV is equally unknown given uncertainty in reservoir parameters, analyst proficiency and techniques used.

Ergo, an MBE feature has been added to GASTOP that provides a convenient and comprehensive means of making a "best estimate" of HCPV. The feature treats an oil reservoir's MBE as the equation of a straight line. The analytical basis for this approach is explained in L.P. Dake's "*fundamentals of reservoir engineering*", Sections 3.3 – 3.7, pp 78 - 97. Given the range of uncertainty in each of the seven parameters listed in the left panel of Figure 1(Each entry is most likely (ML) value, % variation plus or minus) GASTOP's MBE feature uses an error-minimizing procedure (Powell Search) to determine the ML value of each parameter ('Estimated') and the corresponding ML HCPV. The procedure fits a straight line to Y(=F), X(=E) pairs derived from the historical production and reservoir pressure data shown in Figure 2 using test sets of the seven parameters. The blue line in the graph on the lower left is the ML straight line and the red circles are the observed (F, E) points. (F is fluid expansion and E is total underground withdrawal both measured in reservoir barrels.)

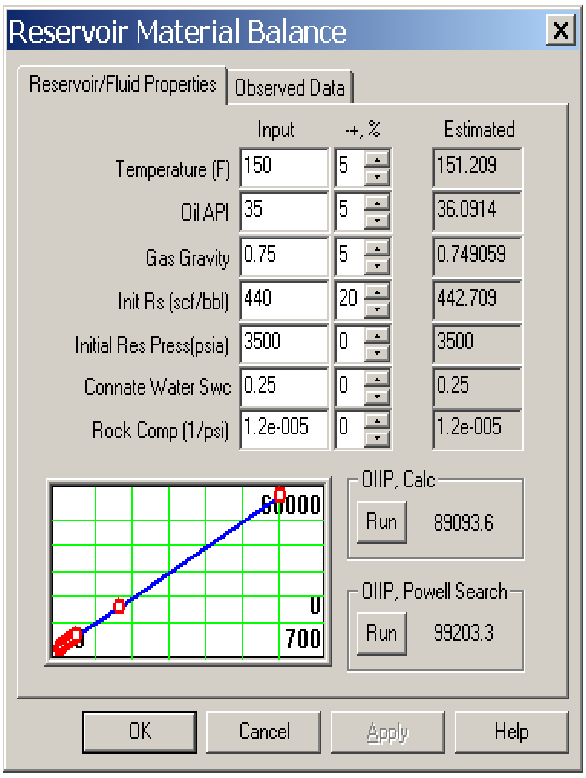


Figure 1

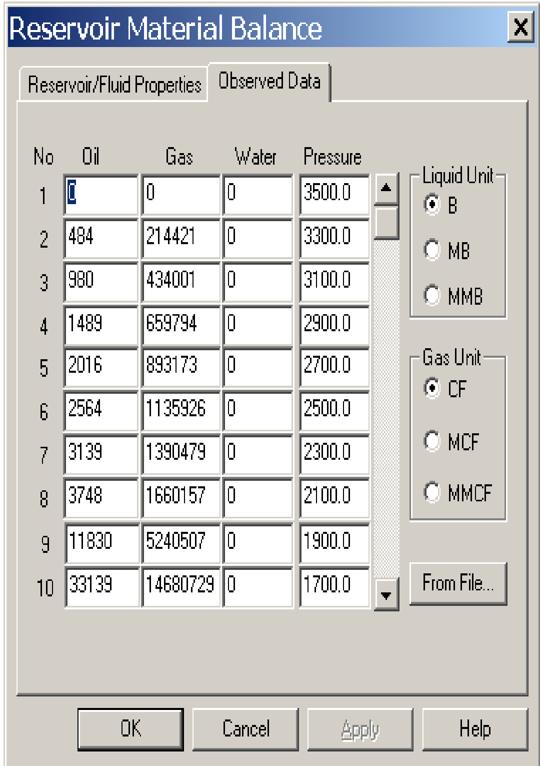


Figure 2

GASTOP'S MBE feature provides several plot options as displayed in Figure 3 shows. The plot of (F/E) vs (1/E) is a particularly useful prescriptive device. A horizontal plot, as shown here, indicates no water influx; a non-horizontal plot indicates some water influx occurred.

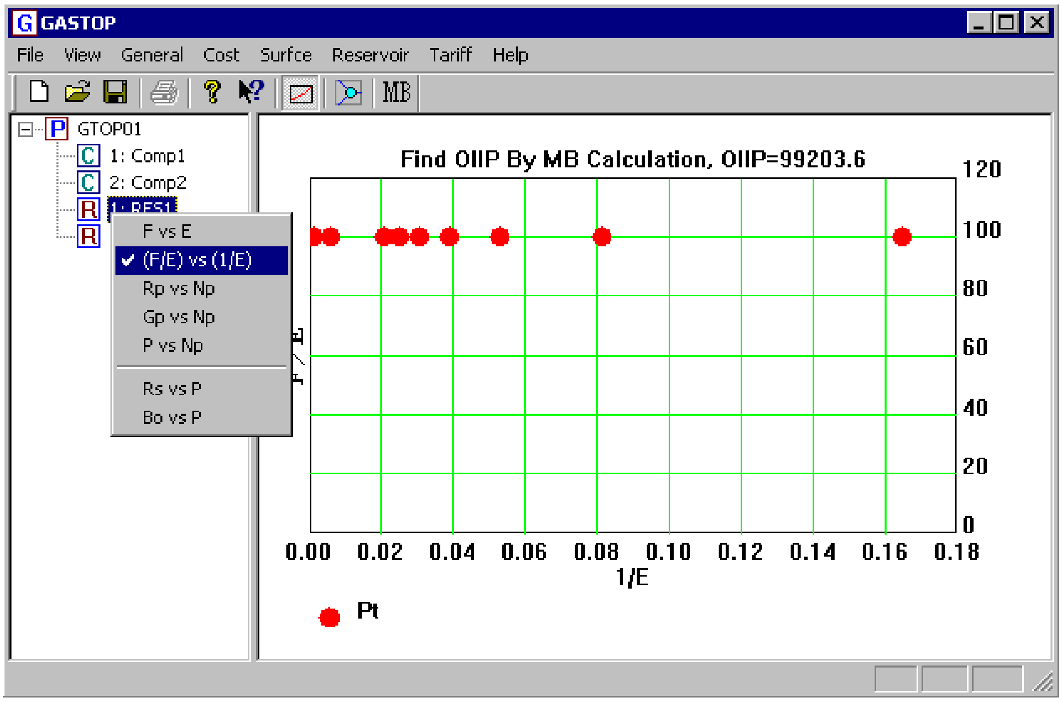


Figure 3

Coming Soon!

The next official release of GASTOP will include the capability for storing and utilizing all pertinent data for the wells. This will include items such as: spud date, surface and bottomhole location, details of the completion string and perforations, all pressure and production data, fluid composition and levels, lithology and pertinent formation characteristics including fracturing and distance to faults. These changes are tied to the latest release of the GMAN, which is now capable of modelling the individual cells of the reservoir.

In addition, Maraco is working with an American storage company to modify GASTOP, so that it can be used as a scheduling tool. The combination of optimal economic design and scheduling will result in a very powerful and versatile gas storage modelling tool.

GaSTop

For further information on GaSTop and our other products and services, please contact:

ETECH International Limited
First Floor, 1 Market Place
Warwick, Warwickshire CV34 4SA England
Tel. + 44 1926 402800
Email: info@etechint.co.uk Website: www.etecint.co.uk