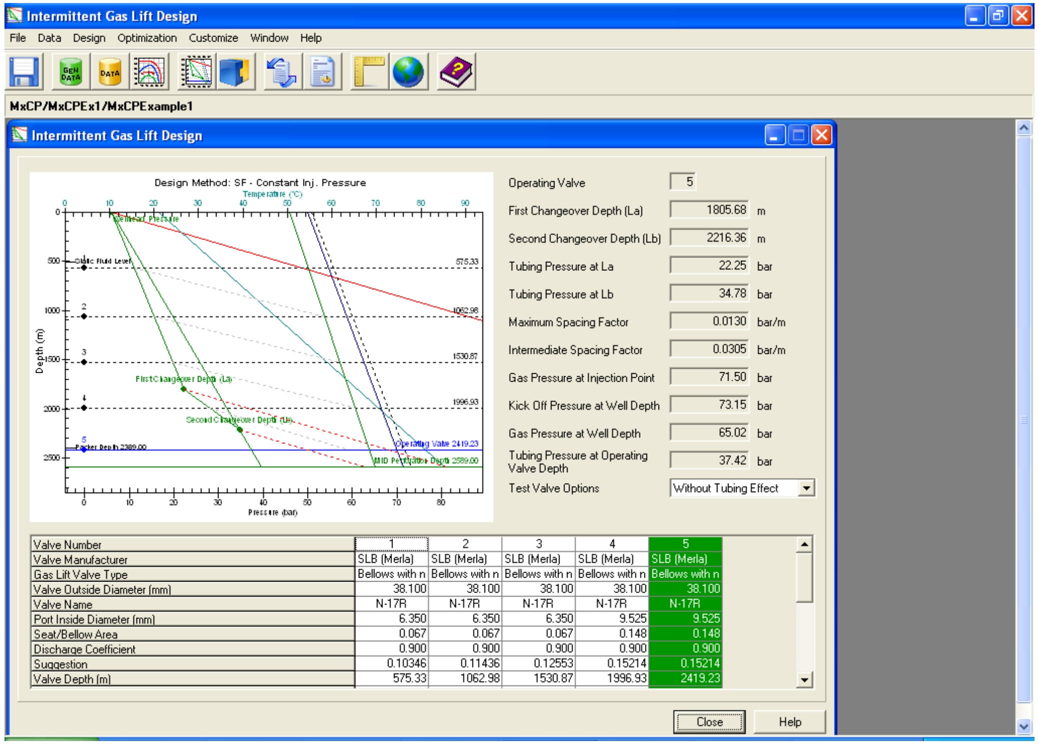
Gas Lift Intermittent Program

sales@cmsprodex.com



Valve Number	1	2	3	4	5
Valve Manufacturer	SLB (Merla)	SLB (Merla)	SLB (Merla)	SLB (Merla)	SLB (Merla)
Gas Lift Valve Type	Bellows with n	Bellows with n	Bellows with n	Bellows with n	Bellows with n
Valve Outside Diameter (mm)	38.100	38.100	38.100	38.100	38.100
Valve Name	N-17R	N-17R	N-17R	N-17R	N-17R
Port Inside Diameter (mm)	6.350	6.350	6.350	9.525	9.525
Seat/Bellow Area	0.067	0.067	0.067	0.148	0.148
Discharge Coefficient	0.900	0.900	0.900	0.900	0.900
Suggestion	0.10346	0.11436	0.12553	0.15214	0.15214
Valve Depth (m)	575.33	1062.98	1530.87	1996.93	2419.23

CMS Prodex have developed the integrated intermittent lift software (***GLIP***) which models the complex intermittent wells operation including simulation of dynamic and highly unsteady – state conditions.

The GLIP program is a powerful and flexible tool used by petroleum engineers to analyze fluid flow in the reservoir and well bore, and to design and optimize intermittent lift operation of oil and gas wells.

Numerous information and data were collected to calibrate developed model and to modify known solutions and to get a model to fit purposes- efficient simulator of intermittent operation.

Application of the model was proved on the fields (*Mexico, Venezuela, Serbia, Hungary etc.*). Information/data were collected and used improved known and applied solutions.

GLIP structure

DES - Data Entry System

Fluid, reservoir and well data base (DB), Equipment - tubing, casing and GLV data base, Injection system, Plunger data.

Tools

PVT package, IPR model, Turner analysis, Reservoir pressure estimation depending on available data.

Intermittent gas lift design and optimization

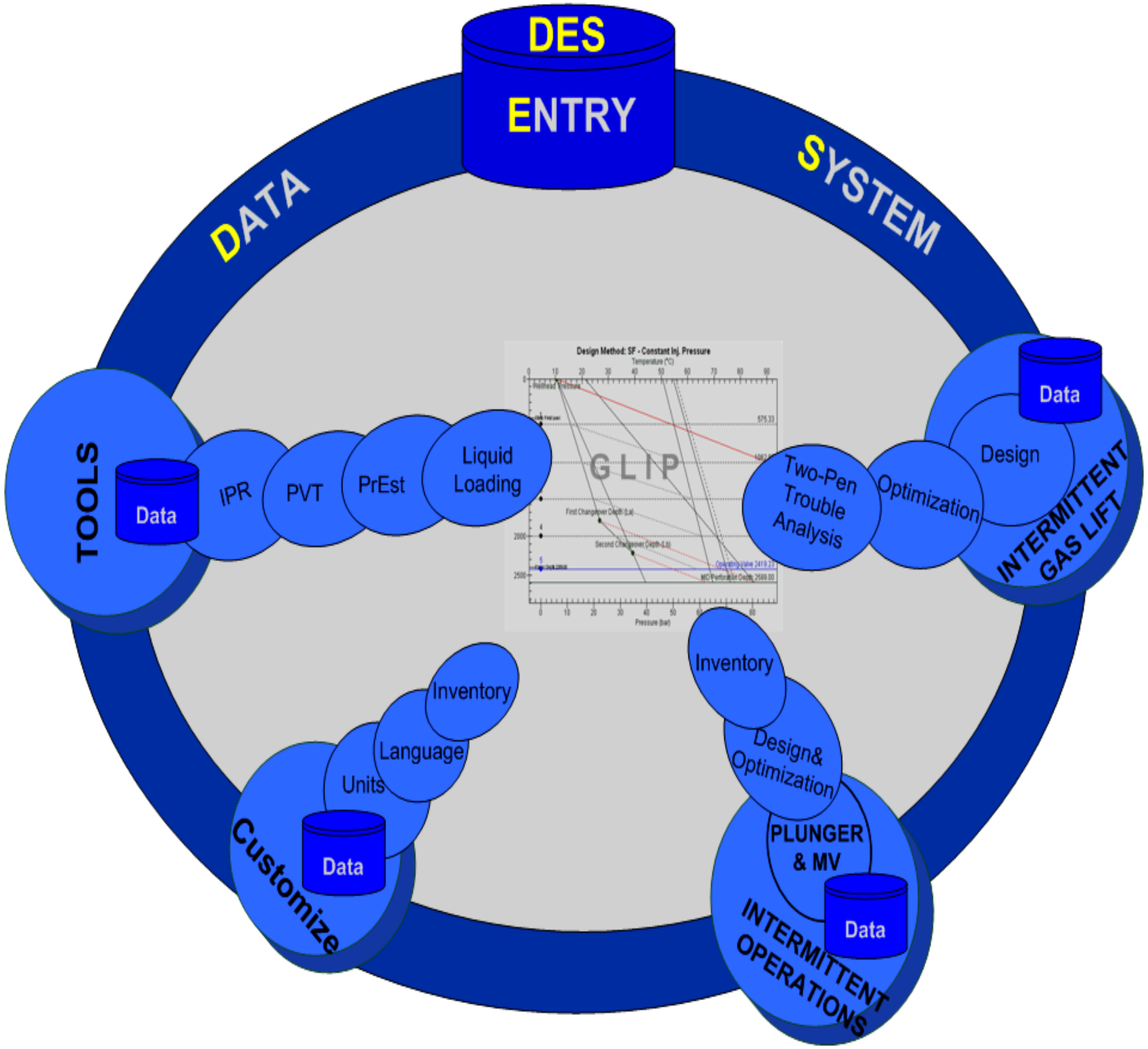
Automatic valve spacing and testing using various models, Optimized cycles

Trouble analysis

Operating valve depth, cycle simulation (number/day, Qginj, Qliq.)

Plunger design and simulation

Cycle, slug height simulation, pressure buildup, final operating parameters



Gas Lift Intermittent Program

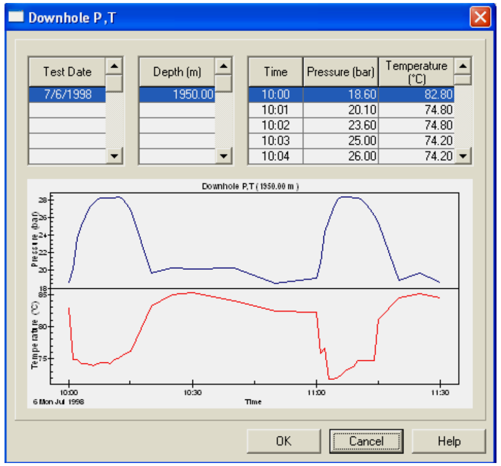
Key features

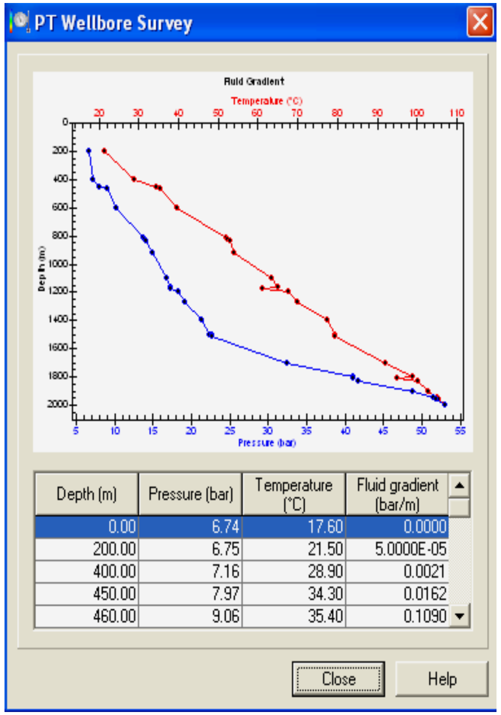
The primary objective of software/suit development was to enable comprehensive analysis of complex well behavior operating intermittently by integrating two apparently separated subsystems into unique model (reservoir/well- hydrodynamic and equipment /mechanic). Model can operate with limited number of information of the reservoir and has ability to predict the performance of well (IPR) if only one test data are available without knowing the reservoir pressure. An intermittent gas lift installation should not considered properly until a two-pen pressures recording instrument has been installed to make daily recording of the tubing and casing pressure.

A control, regulation and problem diagnosis of wells operating intermittently is possible only if measured data are available (surface and bottom). By careful analysis of the tubing and casing pressures, many troubles can be interpreted and corrected without an expense bottom-hole pressures surveys.

Additional features include the detailed analysis of the well and evaluation if the well good candidate for plunger lift application or not (Turner analysis – minimum gas velocity to lift accumulated liquid).

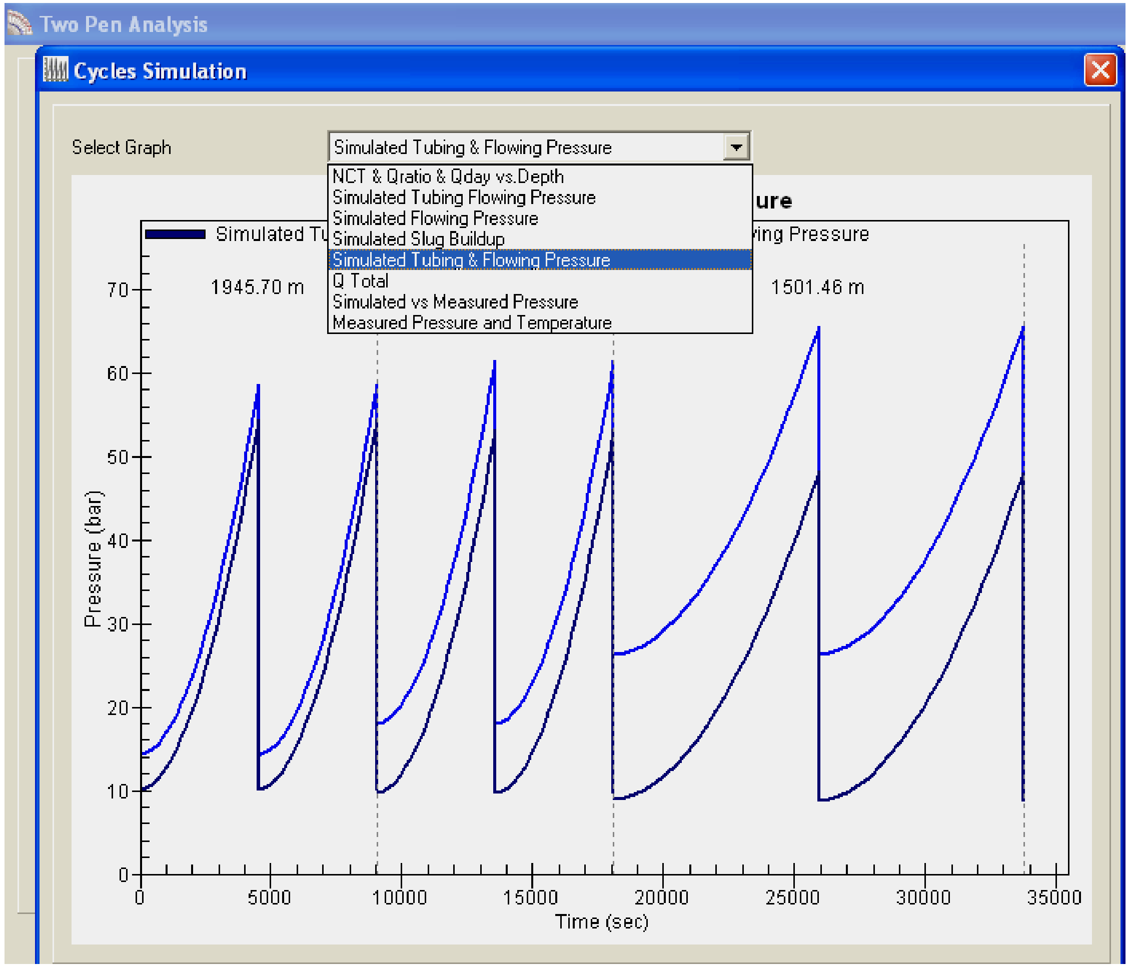
A multitude of design and optimization options offered in GLIP provide you with a great flexibility to analyze or design a system that matches best to yours.





The options include:

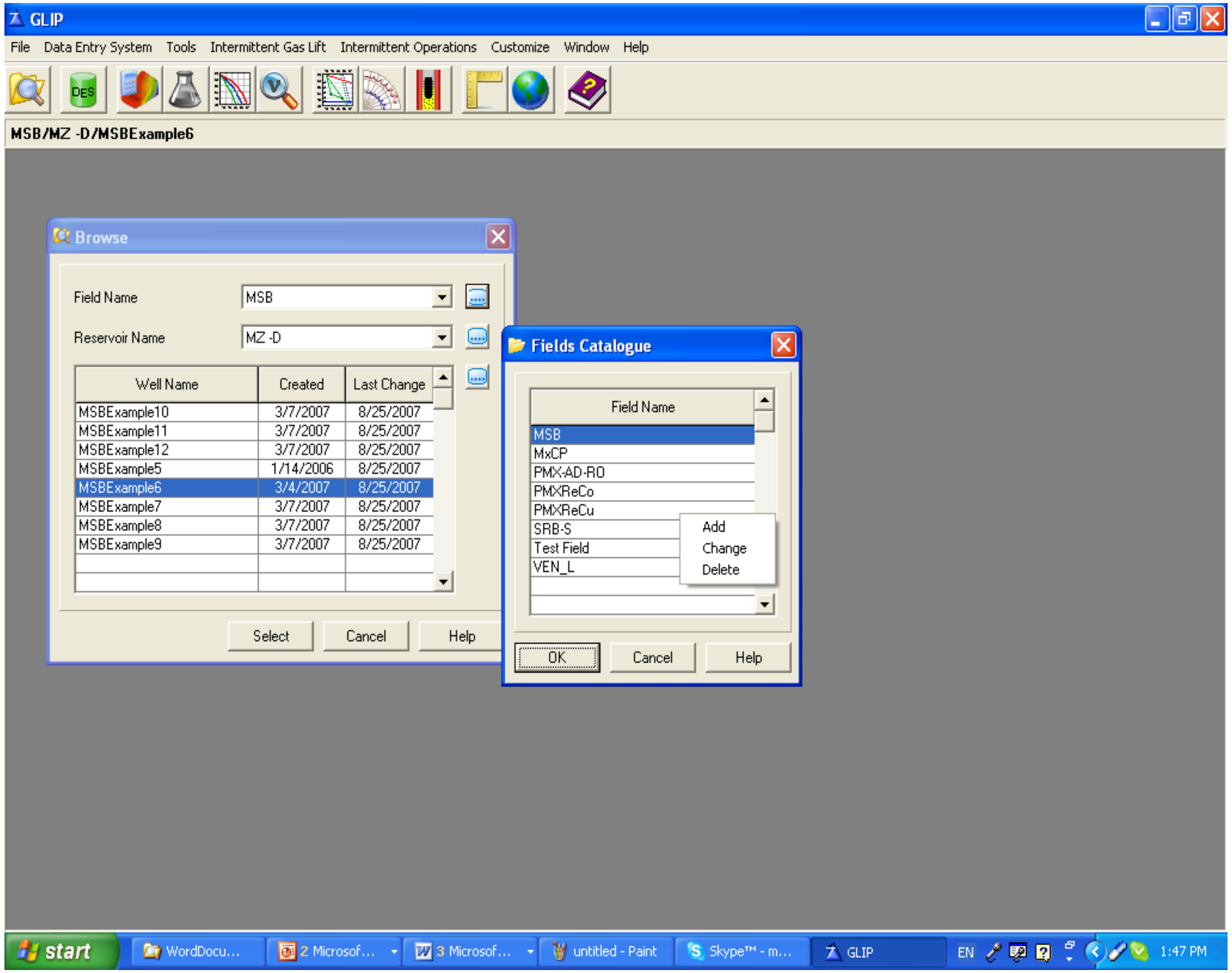
- Designing, optimization, simulation of future conditions and problem analysis of intermittent wells operations
- Simulating pressure buildup during by numerical solution of fluid inflow performance model
- Defining optimal well operating parameters
- Increasing well production efficiency.
- Eliminating requests for downhole pressure survey
- Troubleshooting analysis (Qualitative and Quantitative)
- Comprehensiveness- application in analysis of intermittent gas lift wells at given operating conditions
- Comparison of data on pressure build-up with simulated data
- Simulation of well conditions using minimal number of data (two-pen chart)



Features details

Data Entry System (DES)

GLIP uses hierarchical representation that may be visualized in the data browser. **DES** is generating data base where all data and information are organized in well-defined hierarchy with the ***Data Browser***. At the top of this hierarchy structure is the system for entering, editing and deleting field, reservoir and well data.



Well data are classified to:

- General well information
- Well Geometry
- Completion data
- Fluid Properties
- Reservoir properties
- General information about surface conditions
- Measurements (production tests, trajectory and surface pressure test, downhole P&T)

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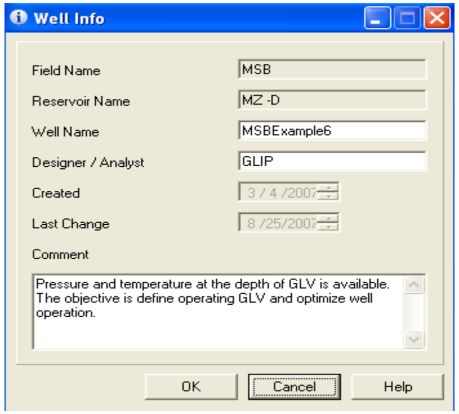
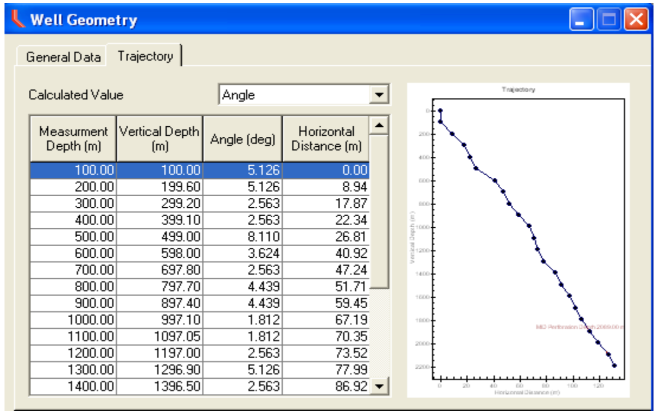
Glip

General well information

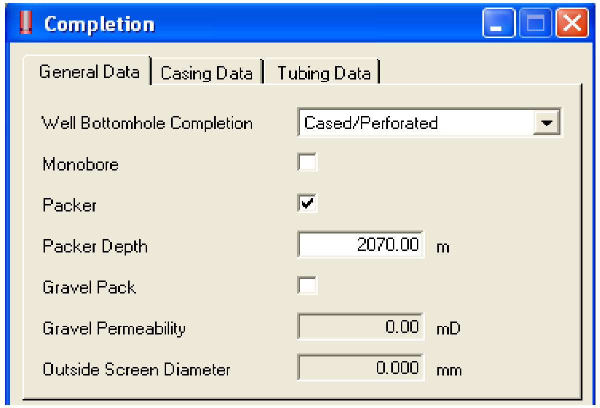


Well Geometry

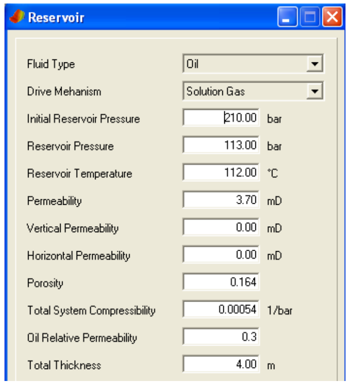


Measurment Depth (m)	Vertical Depth (m)	Angle (deg)	Horizontal Distance (m)
100.00	100.00	5.126	0.00
200.00	199.60	5.126	8.94
300.00	299.20	2.563	17.87
400.00	399.10	2.563	22.34
500.00	499.00	8.110	26.81
600.00	598.00	3.624	40.92
700.00	697.80	2.563	47.24
800.00	797.70	4.439	51.71
900.00	897.40	4.439	59.45
1000.00	997.10	1.812	67.19
1100.00	1097.05	1.812	70.35
1200.00	1197.00	2.563	73.52
1300.00	1296.90	5.126	77.99
1400.00	1396.50	2.563	86.92

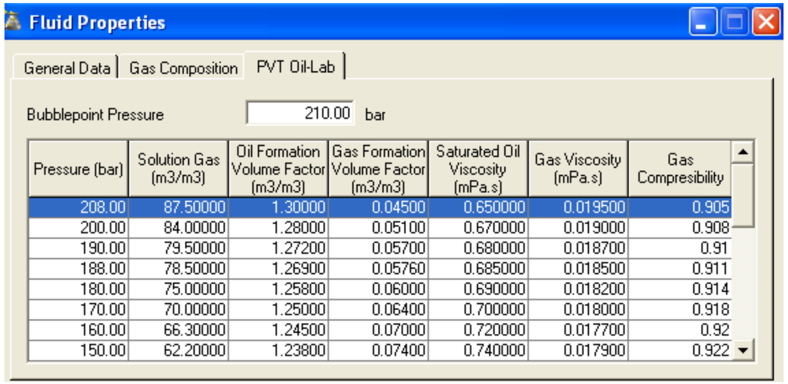
Completion data



Reservoir properties



Fluid characteristics



Pressure (bar)	Solution Gas (m3/m3)	Oil Formation Volume Factor (m3/m3)	Gas Formation Volume Factor (m3/m3)	Saturated Oil Viscosity (mPa.s)	Gas Viscosity (mPa.s)	Gas Compressibility
208.00	87.50000	1.30000	0.04500	0.650000	0.019500	0.905
200.00	84.00000	1.28000	0.05100	0.670000	0.019000	0.908
190.00	79.50000	1.27200	0.05700	0.680000	0.018700	0.91
188.00	78.50000	1.26900	0.05760	0.685000	0.018500	0.911
180.00	75.00000	1.25800	0.06000	0.690000	0.018200	0.914
170.00	70.00000	1.25000	0.06400	0.700000	0.018000	0.918
160.00	66.30000	1.24500	0.07000	0.720000	0.017700	0.92
150.00	62.20000	1.23800	0.07400	0.740000	0.017900	0.922

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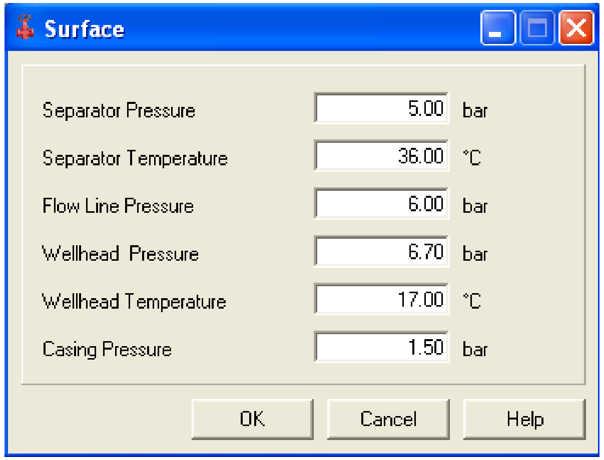
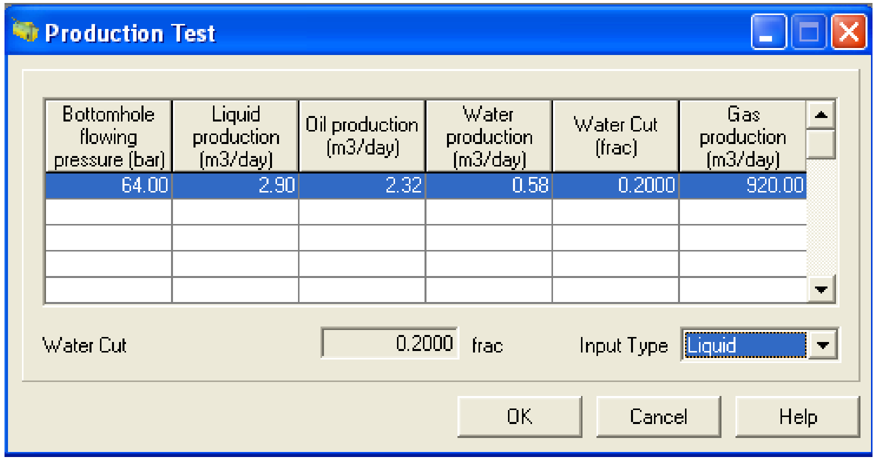
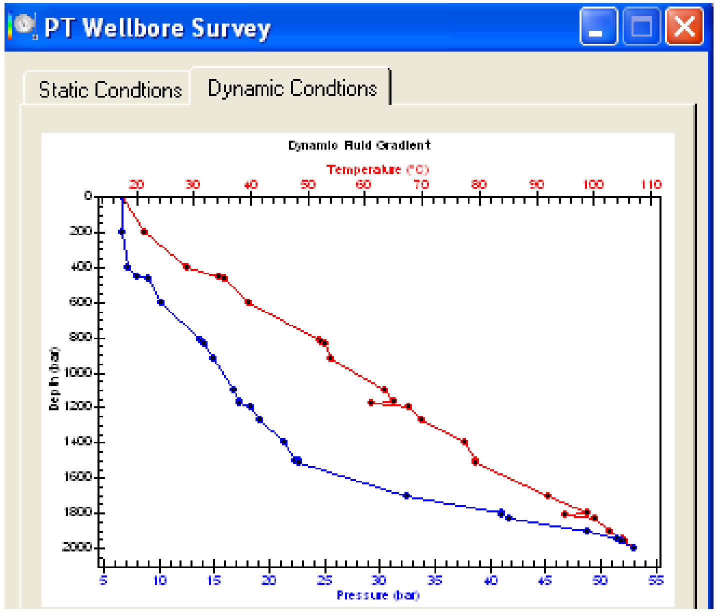
Surface conditions



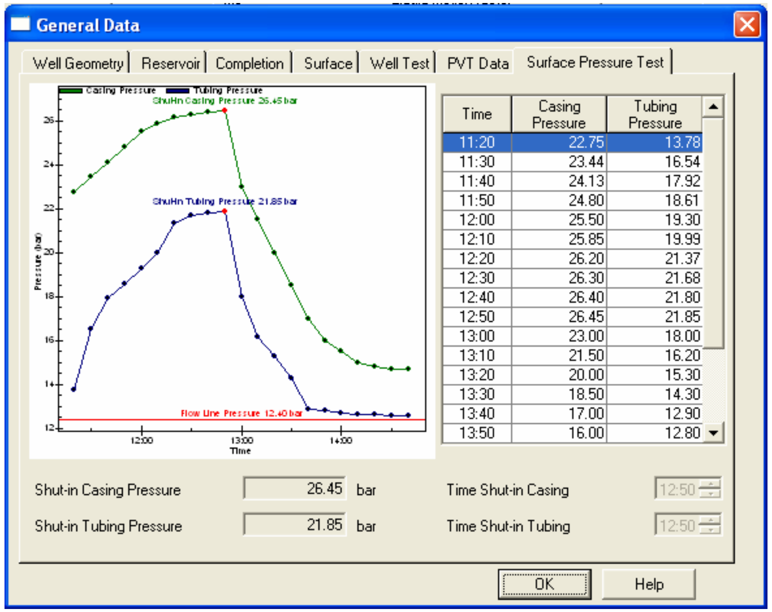
Downhole P&T



Production tests



Surface pressure test



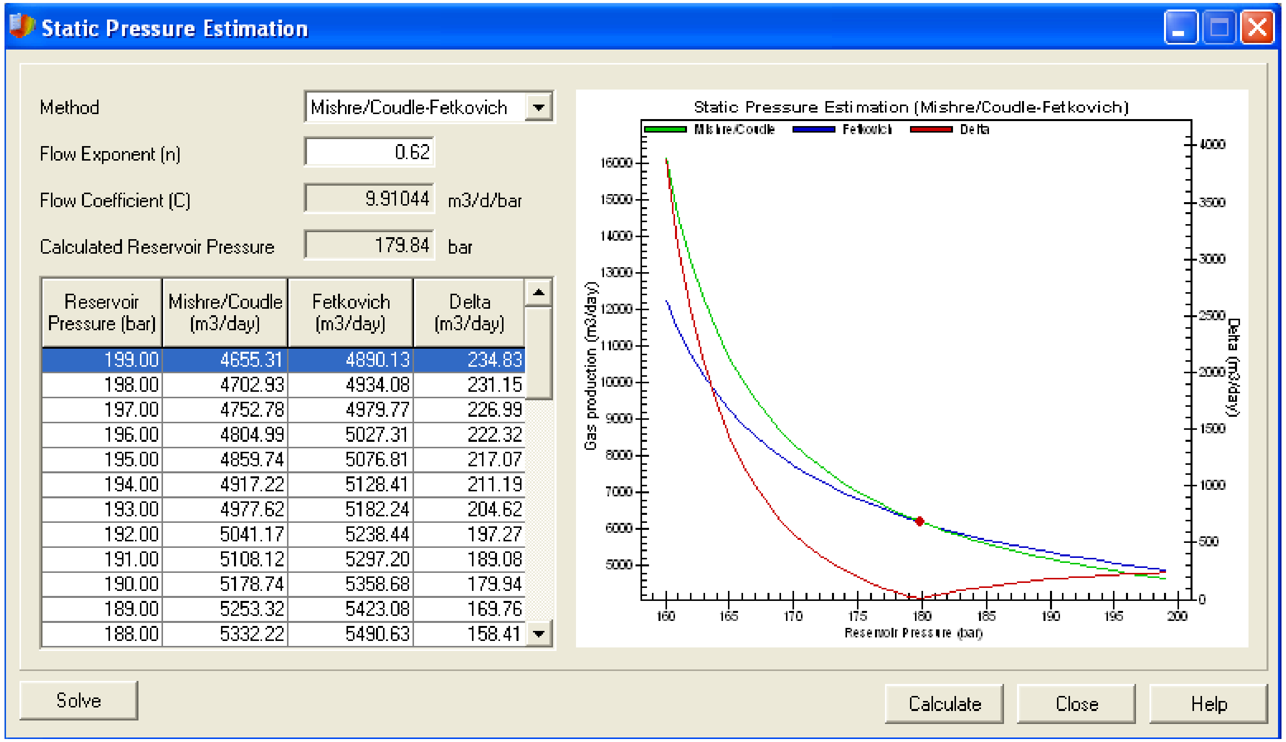
Tools

Static pressure estimation

In the case when static pressure is not known, the developed tool is able to determine a probable value of static pressure by using measurement data. If only one test is available (rate/pressure), model is resolving the set of IPR equations trying to find for which assumed flow exponent or laminar flow coefficients, the difference between two various methods is minimum. The process of calculation can be completely under control of system, or user can give the best estimation, and program will calculate the most probably static pressure.

If two or more test rates are known the accuracy of static pressure estimation is higher and very close to the real reservoir pressure.

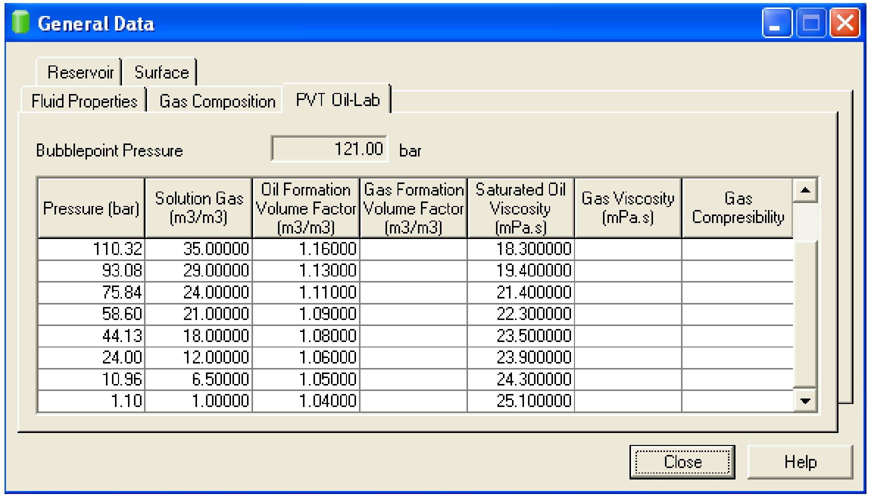
Unknown inflow parameters (flow exponent, flow coefficients) can be calculated and determine uniquely.



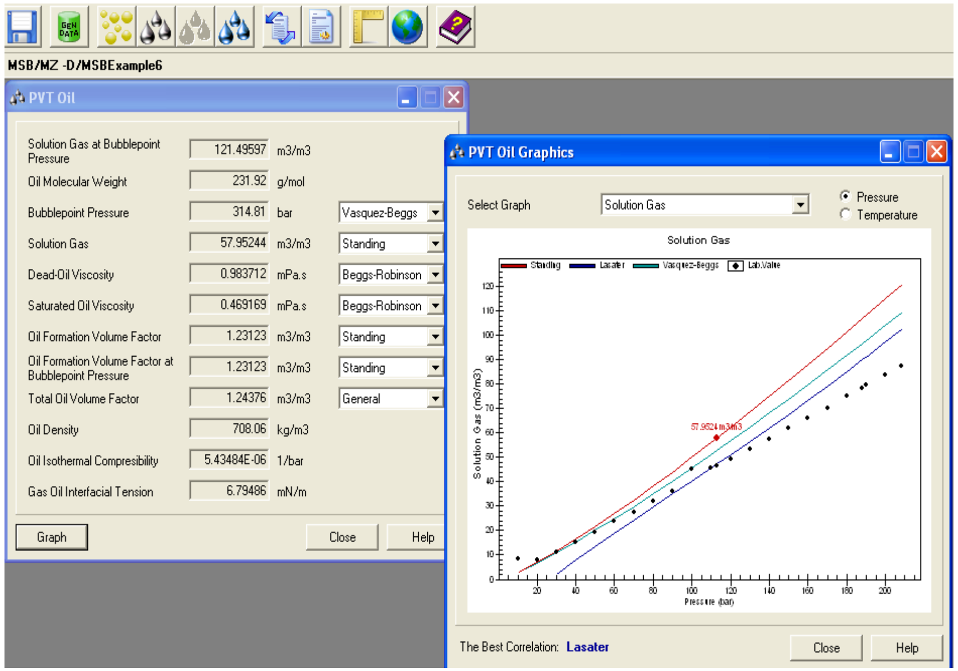
Fluid Physical Characteristics and PVT

The program establishes the valid black oil PVT correlations for oil, gas, condensates and water.

Correlations can be automatically matched with measured data. Since gas evaluation in the tubing is a constant composition process, flash data, not differential liberation, should be used for matching. The temperature and bubble point should be entered to match the data given in table.



Pressure (bar)	Solution Gas (m3/m3)	Oil Formation Volume Factor (m3/m3)	Gas Formation Volume Factor (m3/m3)	Saturated Oil Viscosity (mPa.s)	Gas Viscosity (mPa.s)	Gas Compresibility
110.32	35.00000	1.16000		18.300000		
93.08	29.00000	1.13000		19.400000		
75.84	24.00000	1.11000		21.400000		
58.60	21.00000	1.09000		22.300000		
44.13	18.00000	1.08000		23.500000		
24.00	12.00000	1.06000		23.900000		
10.96	6.50000	1.05000		24.300000		
1.10	1.00000	1.04000		25.100000		



Oil

Correlations used for oil bubble pressure (***Pb***), solution gas (*Rs*) and oil formation factor (Bo) are: ***Standing***, ***Lasater***, ***Vasquez-Beggs***, ***Glaso***, ***MECO*** (*Middle East Crude Oils*).

PVT module calculates live and dead oil viscosity using **Beggs-Robinson**, **Beal** and **Chew Connelly** correlations. Calculations of density of live and dead oil are included, also.

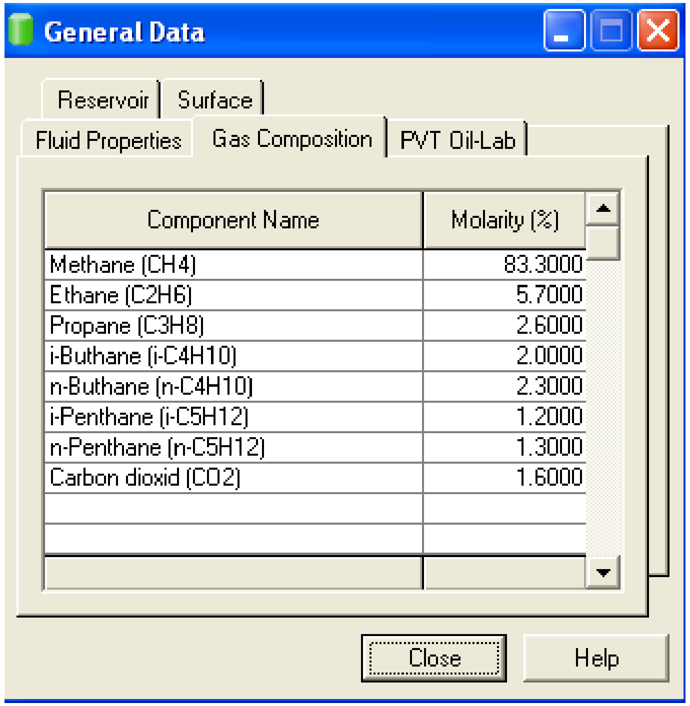
Reservoir water

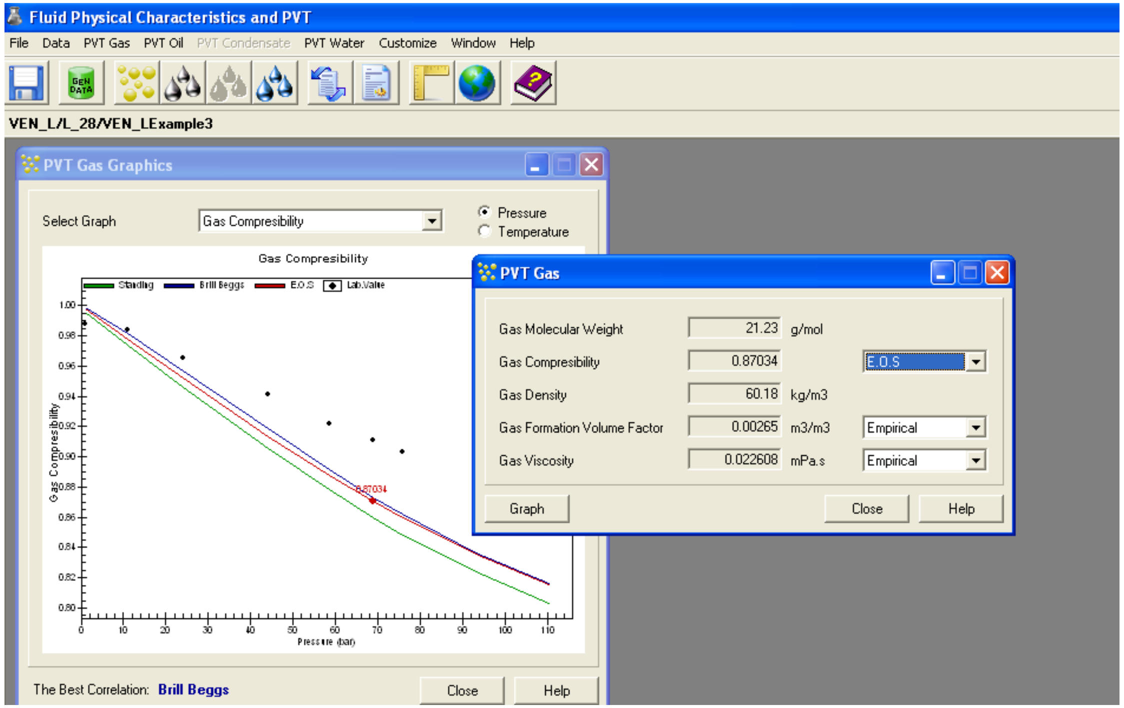
Knowing solids content reservoir water density, formation factor and interfacial can be calculated and used for loading process analyzes.

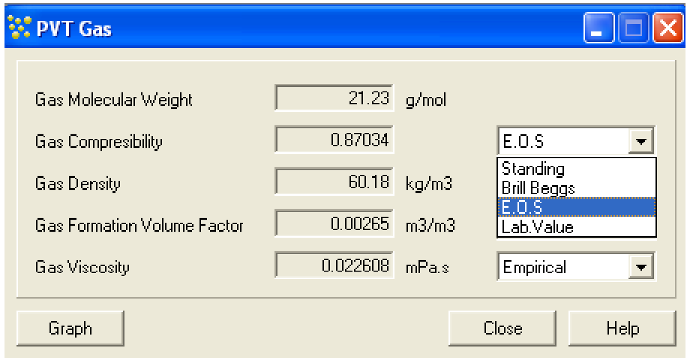
Gas / Condensate

The necessary calculation properties of reservoir and dry injection gases are applied. When gas is selected as the PVT option, it is requested to enter composition either reservoir or dry injection gas, as is displayed on the input data screen.

To simulate gas behavior at various P &T conditions the analytical ***Standing*** and ***Brill – Beggs*** correlation user can select, or use solution of ***EOS***, proposed by Hall and Yarborough (OGJ, June, 1973).

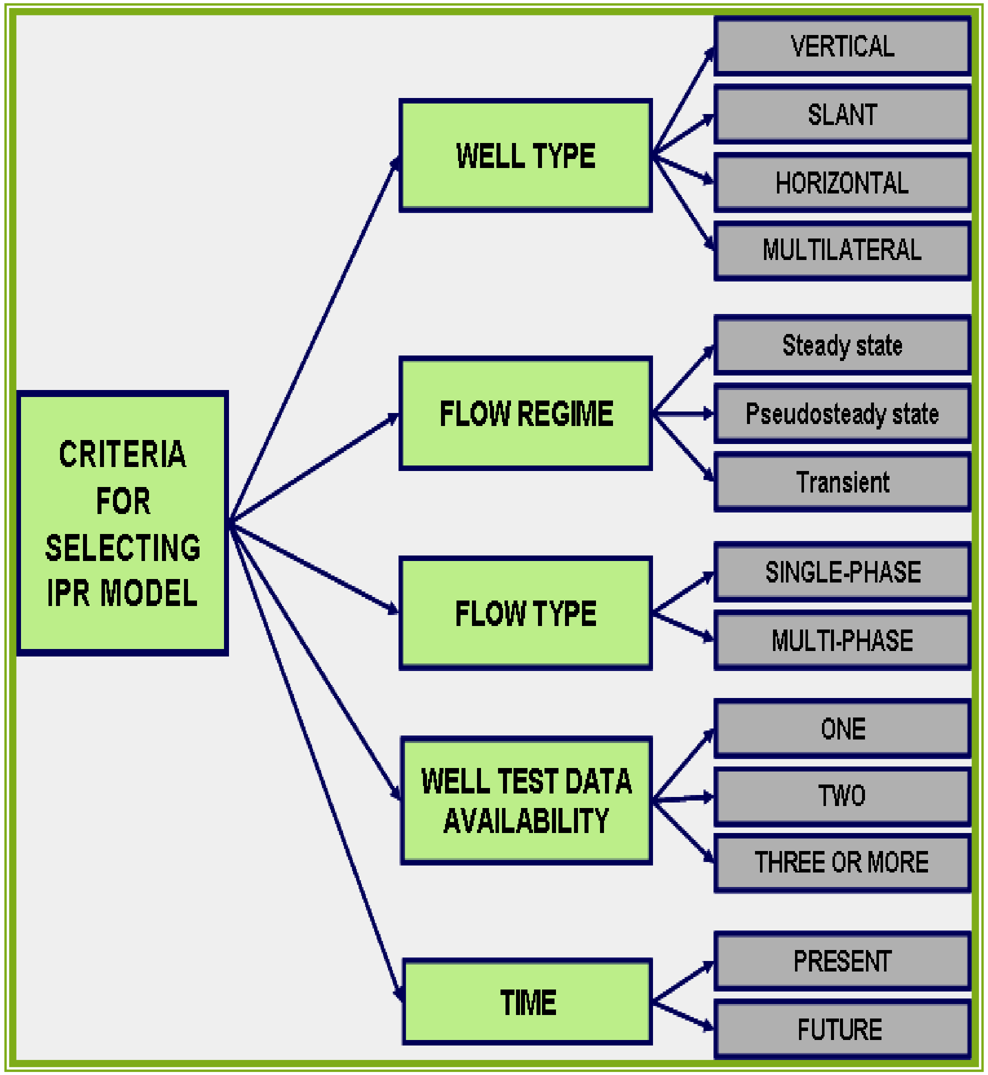






Inflow performance relationship

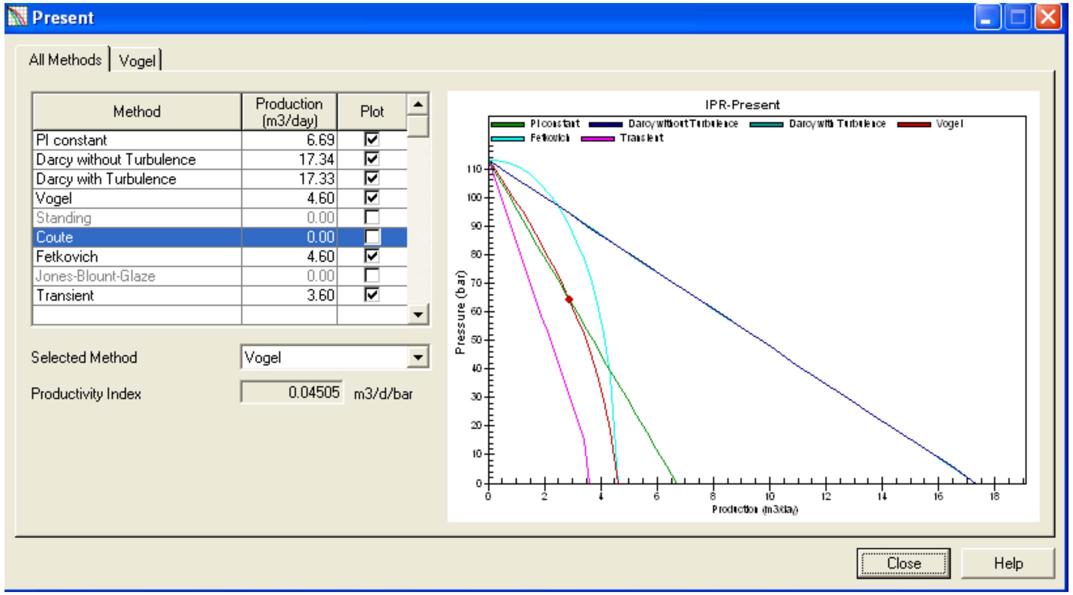
The Inflow Performance Relationship (IPR) is the production engineer's shorthand description of the performance of a well at a given reservoir pressure. IPR is the relationship between the bottomhole flowing pressure and flow rates, and it is the starting point in the analysis of a well's behavior. IPR includes the effects of both reservoir and completion efficiency. The shape of the IPR curve and the method that will be used to establish the relation between the flowing bottomhole pressures and flow rates depend on many factors, like relation between reservoir and saturation pressures (single or two-phase flow), physical characteristics of the reservoir and fluids etc. When the flowing pressure in the formation falls below the bubble point (Pb), gas comes out of solution, reduces the permeability to the oil phase, decreases the productivity index, and reduces the oil flow rate within formation. At increased production rates, Pwf decreases and more gas comes out of solution within reservoir, and the relative permeability to oil decreases.

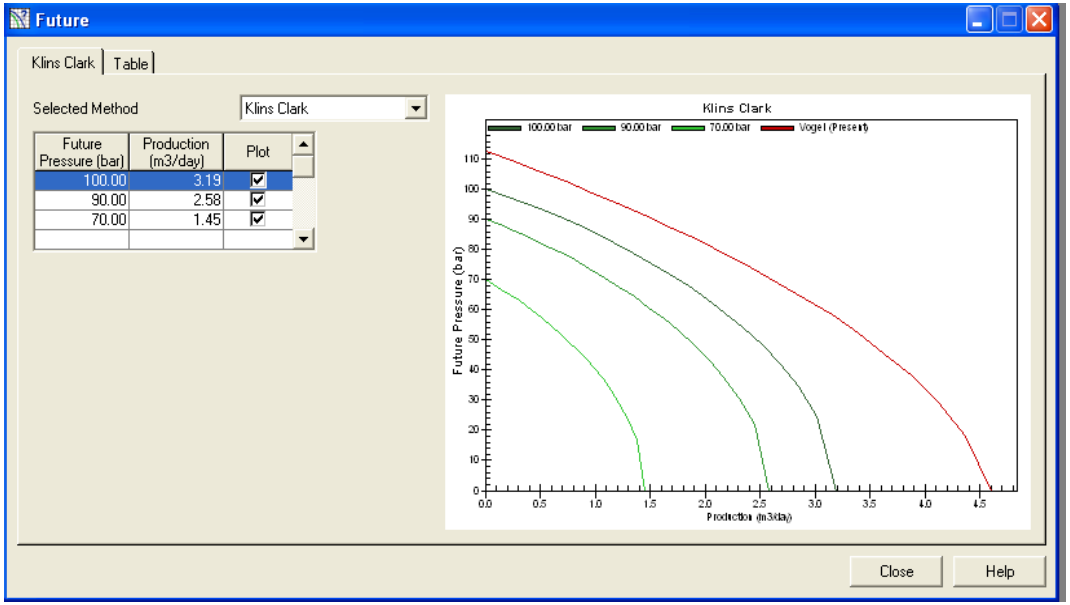


Other factors such as increased oil viscosity, rock compressibility, and turbulence can add to these effects as wellbore pressures fall and rates increase. The IPR evaluation method selection depending on the flow type and regime as well as well geometry (vertical / slant / horizontal).

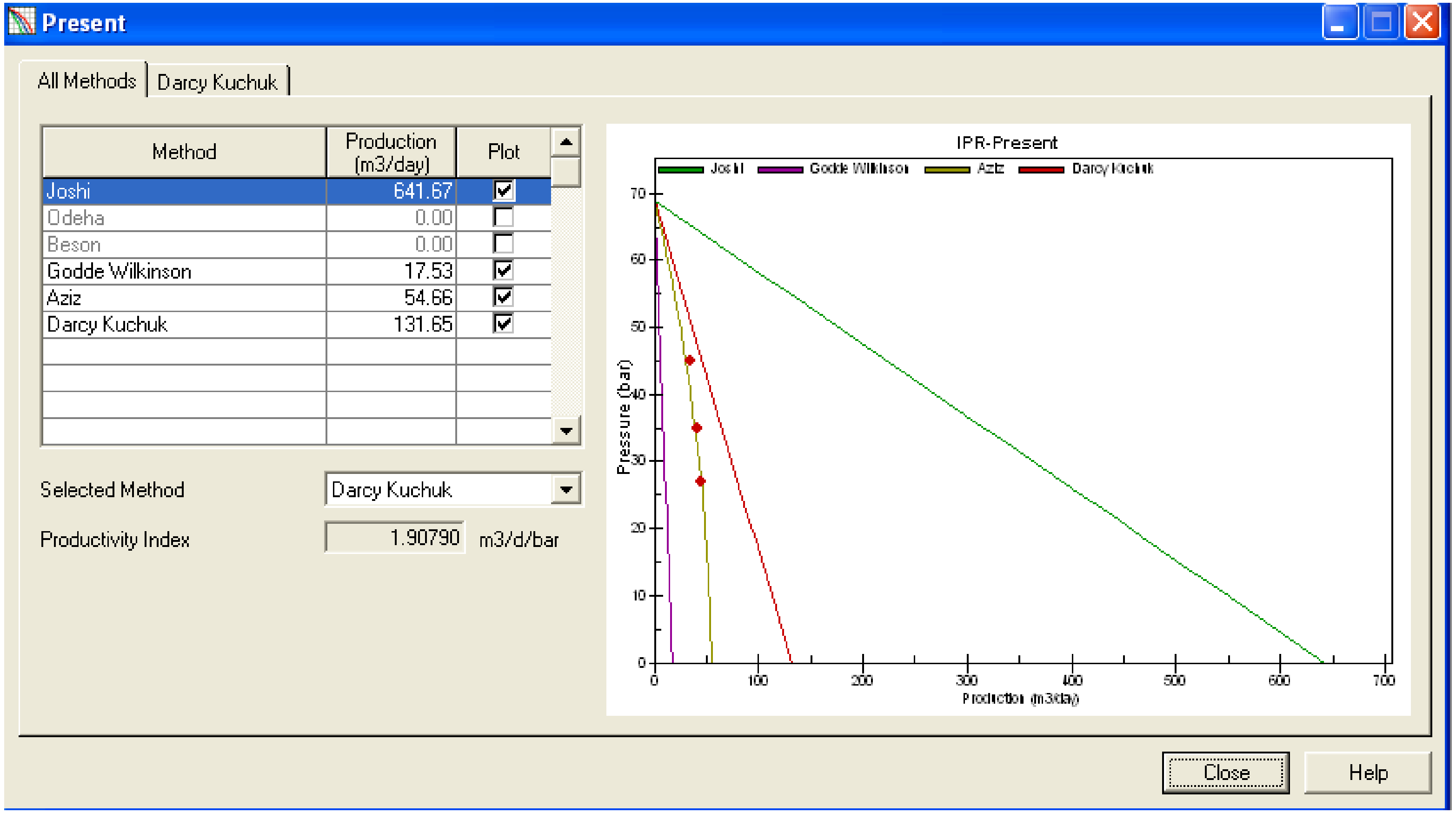
Selection of the IPR method is strongly depending on data entered in DES and data required only for IPR modeling. GLIP is controlling the availability of data, as well as the data quality. As results of such checking, the system will select only that models for which there are enough information. If there is not needed information for particular model, on report screen it can be seen that calculated AOFP is 0.

Future IPR performance can be used to design intermittent operation for expected conditions.





If trajectory data have been entered, then system is analyzing information and using build-in rules will decide which type of well was drilled through productive zone. According to results of checking and analyzes, system will recognized the well geometry and will choose the corresponding IPR models (vertical, slant or horizontal). To continue with design program is asking to select IPR method that will be used for all other purposes (design, trouble analysis and optimization).



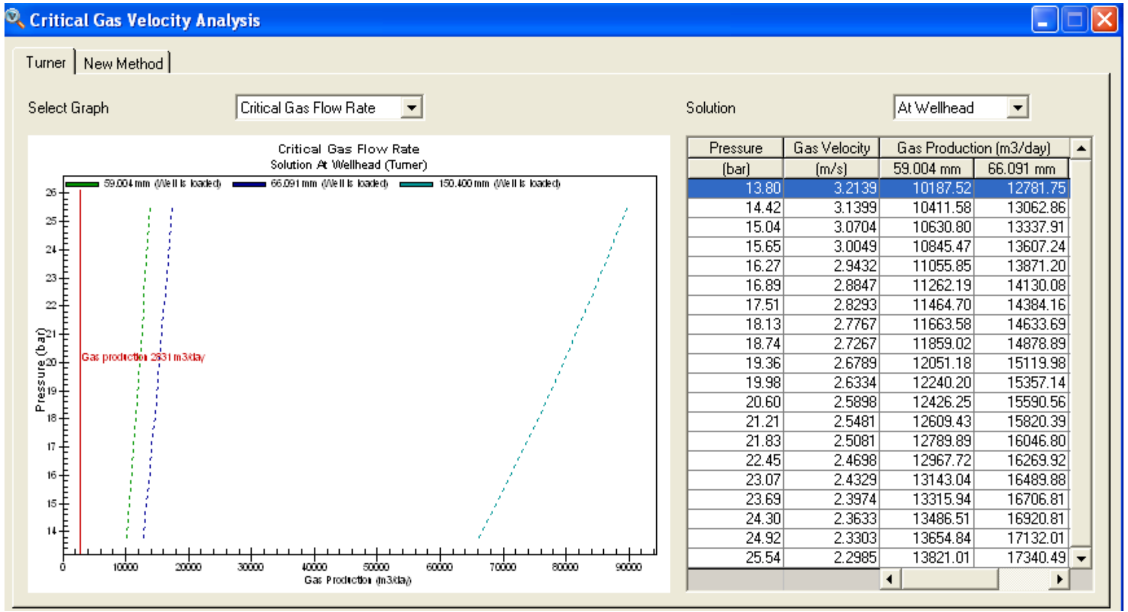
Critical gas velocity analysis

One of the most important aspects in the investigations of the liquid-loading phenomena in the gas wells has been focused on how predict the critical gas flow rate or production parameters under which liquid entrainment is impossible.

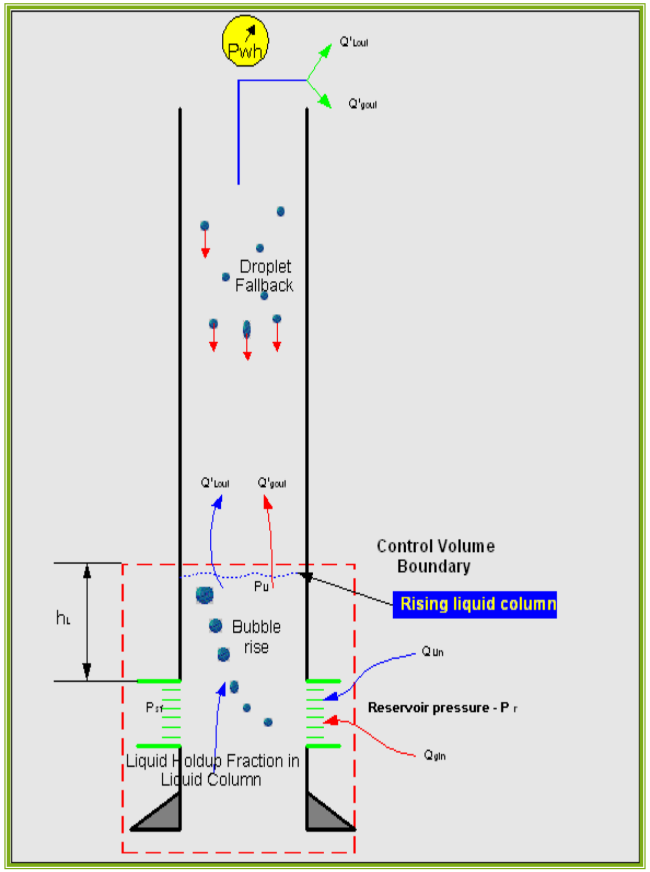
Program calculates the critical /minimum gas velocity required to keep well with liquid accumulation. Two methods are used:

- *Turner*
- *Modified Turner method (SPE 75455)*

As results of calculation program gives the dependence of critical gas velocity for various tubing size for cases, wellhead and bottomhole.



Pressure	Gas Velocity	Gas Production (m3/day)	
(bar)	(m/s)	59.004 mm	66.091 mm
13.80	3.2139	10187.52	12781.75
14.42	3.1399	10411.58	13062.86
15.04	3.0704	10630.80	13337.91
15.65	3.0049	10845.47	13607.24
16.27	2.9432	11055.85	13871.20
16.89	2.8847	11262.19	14130.08
17.51	2.8293	11464.70	14384.16
18.13	2.7767	11663.58	14633.69
18.74	2.7267	11859.02	14878.89
19.36	2.6789	12051.18	15119.98
19.98	2.6334	12240.20	15357.14
20.60	2.5898	12426.25	15590.56
21.21	2.5481	12609.43	15820.39
21.83	2.5081	12789.89	16046.80
22.45	2.4698	12967.72	16269.92
23.07	2.4329	13143.04	16489.88
23.69	2.3974	13315.94	16706.81
24.30	2.3633	13486.51	16920.81
24.92	2.3303	13654.84	17132.01
25.54	2.2985	13821.01	17340.49



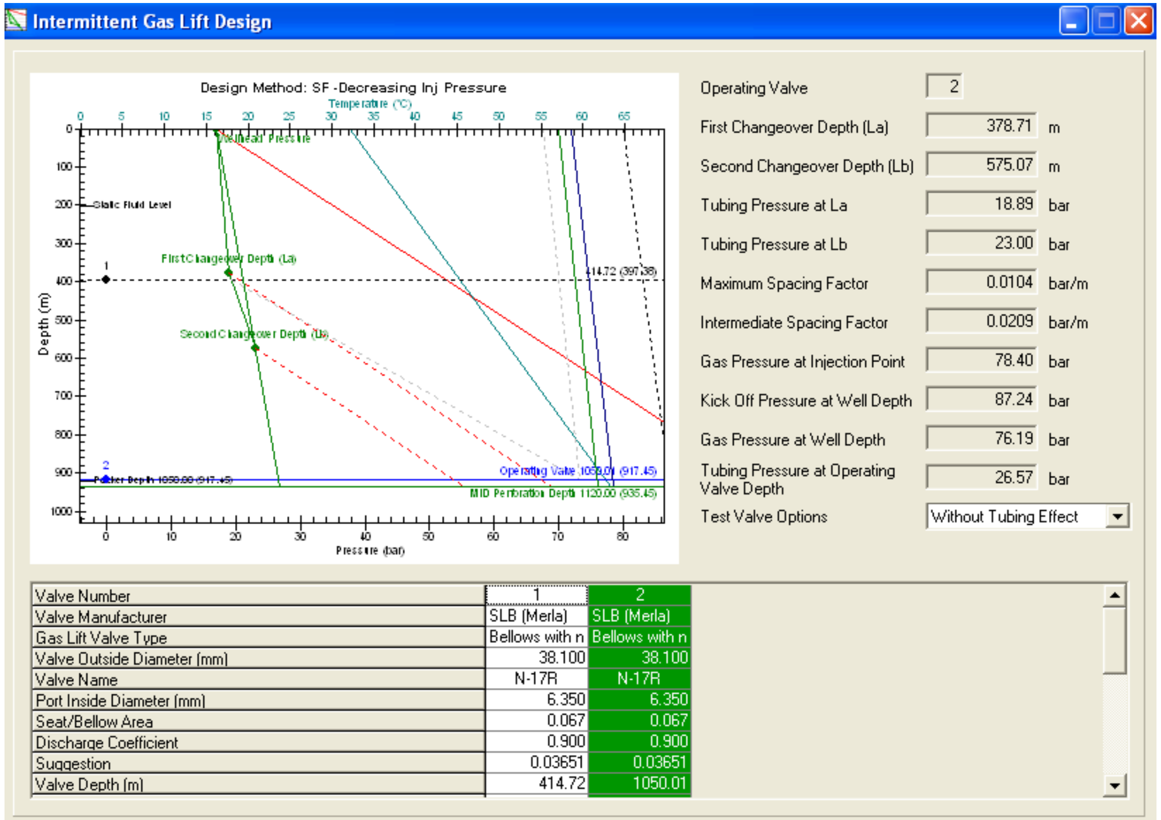
Intermittent gas lift design

Intermittent gas lift design includes the evaluation of the following parameters: valves setting depth and characteristics of gas lift valves. The setting depths and characteristics of gaslift valves can be evaluated graphically and analytically.

There are various methods for designing intermittent lift installations. Most of them fall into two basic categories:

- Design based on Intermittent Spacing Factor (constant and decrease gas lift valve surface closing pressure).
- Design based on ratio tubing and casing pressure (“Percent Load" and “Opti-flow" methods)

The spacing factor method is recommended for the wells with known inflow characteristics. This method requires the largest number of input data. The depth of the operating valve is automatically evaluated as the explicit function of the reservoir and flowing bottom-hole pressures and the static and flowing gradients.



The tubing / injection pressure method requires minimum information on the reservoir. The designer designates the operating valve taking into account the tubing / injection pressure at valve opening.

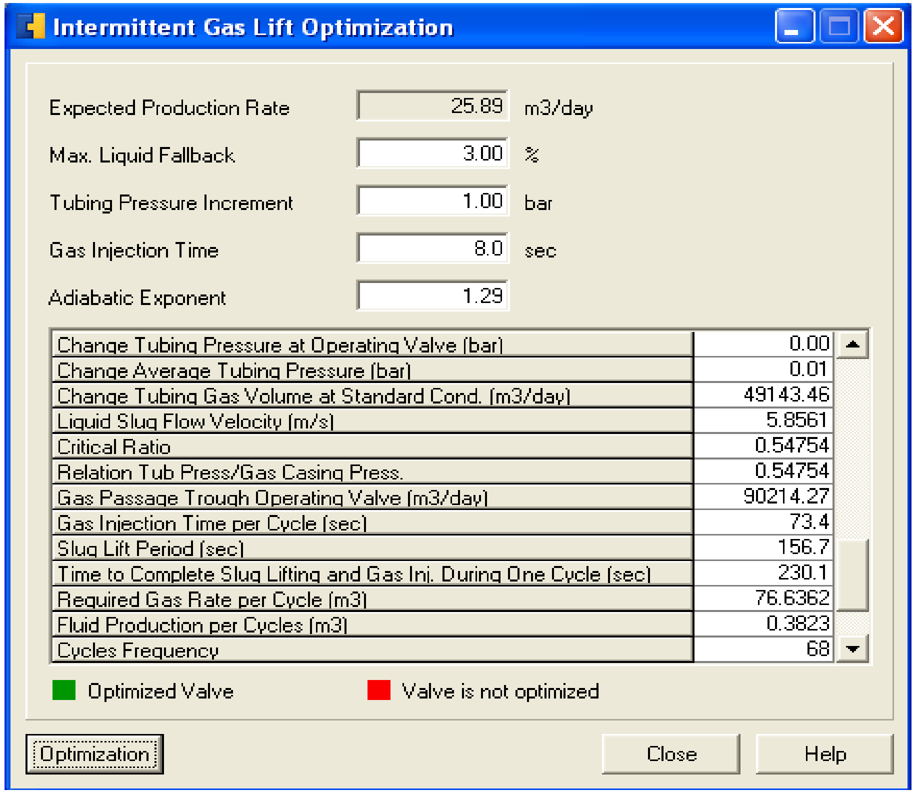
Glip

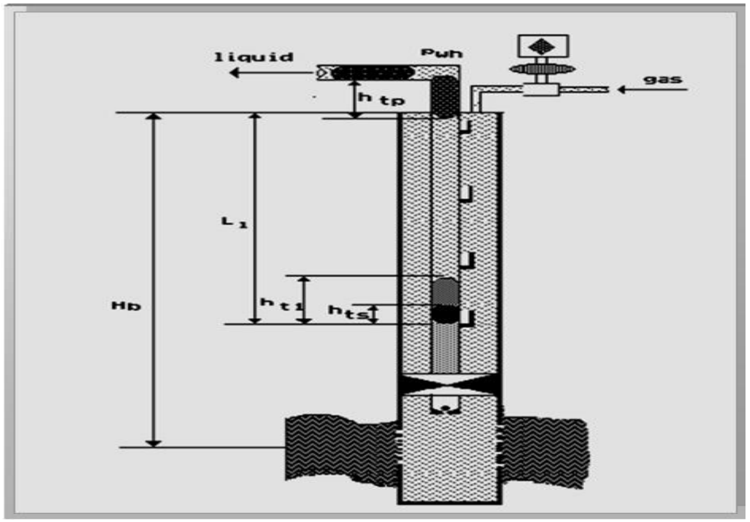
Intermittent gas lift optimization

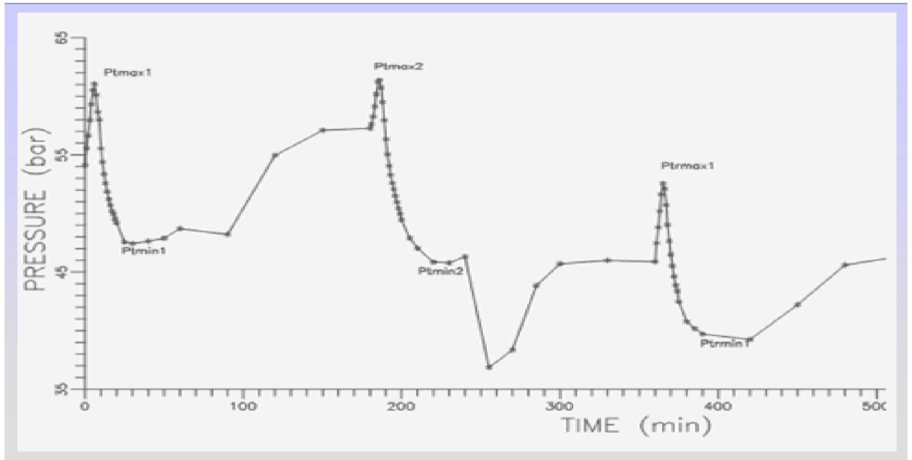
The most important dynamic parameters that should be determined are in order to optimize the well operation are:

- The gas flow rate flowing through gas lift valve,
- The velocity of the liquid slug lifted with gas,
- The liquid volume surfacing in slug form,
- The dispersed liquid volume,
- Cycle per day
- The changes of the flowing bottom-hole pressure.

An important part of dynamic parameters consideration is evaluation of the velocity with which a gas bubble penetrates liquid above in tubing.



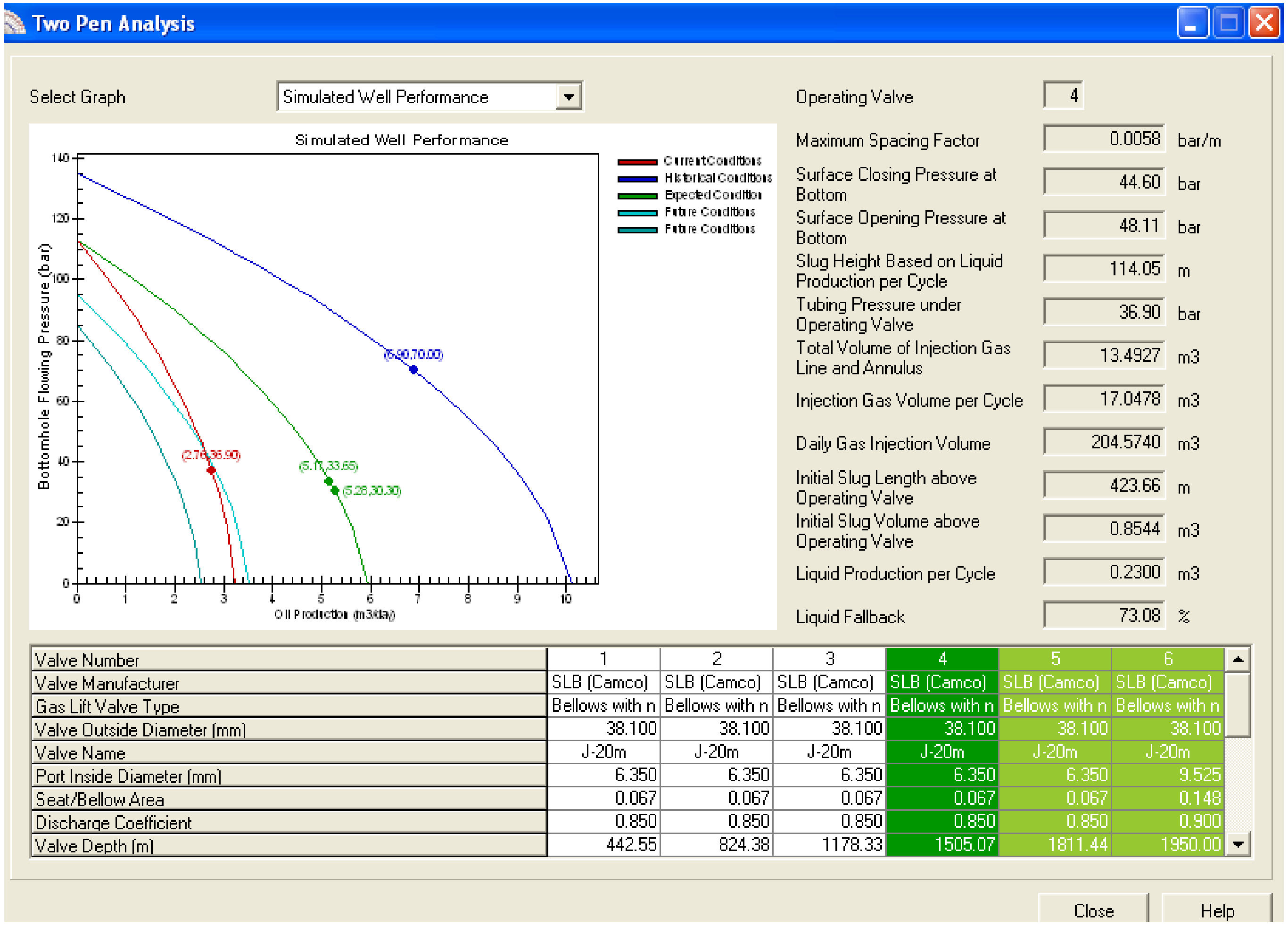




Trouble Analysis

An intermittent gas lift installation should not considered properly until a two-pen pressures recording instrument has been installed to make daily recording of the tubing and casing pressure. By careful study of the tubing and casing pressures, many troubles may be interpreted and corrected without the expense of pressures surveys or tubing jobs.

The knowledge of well operation regulation and control in intermittent gas lift is possible only if the data for measuring tubing / casing pressures and for measuring bottom hole flowing pressure are available; this was the basis for acquiring the sufficient number of data which were the foundation of a intermittent gas lift well performance study.

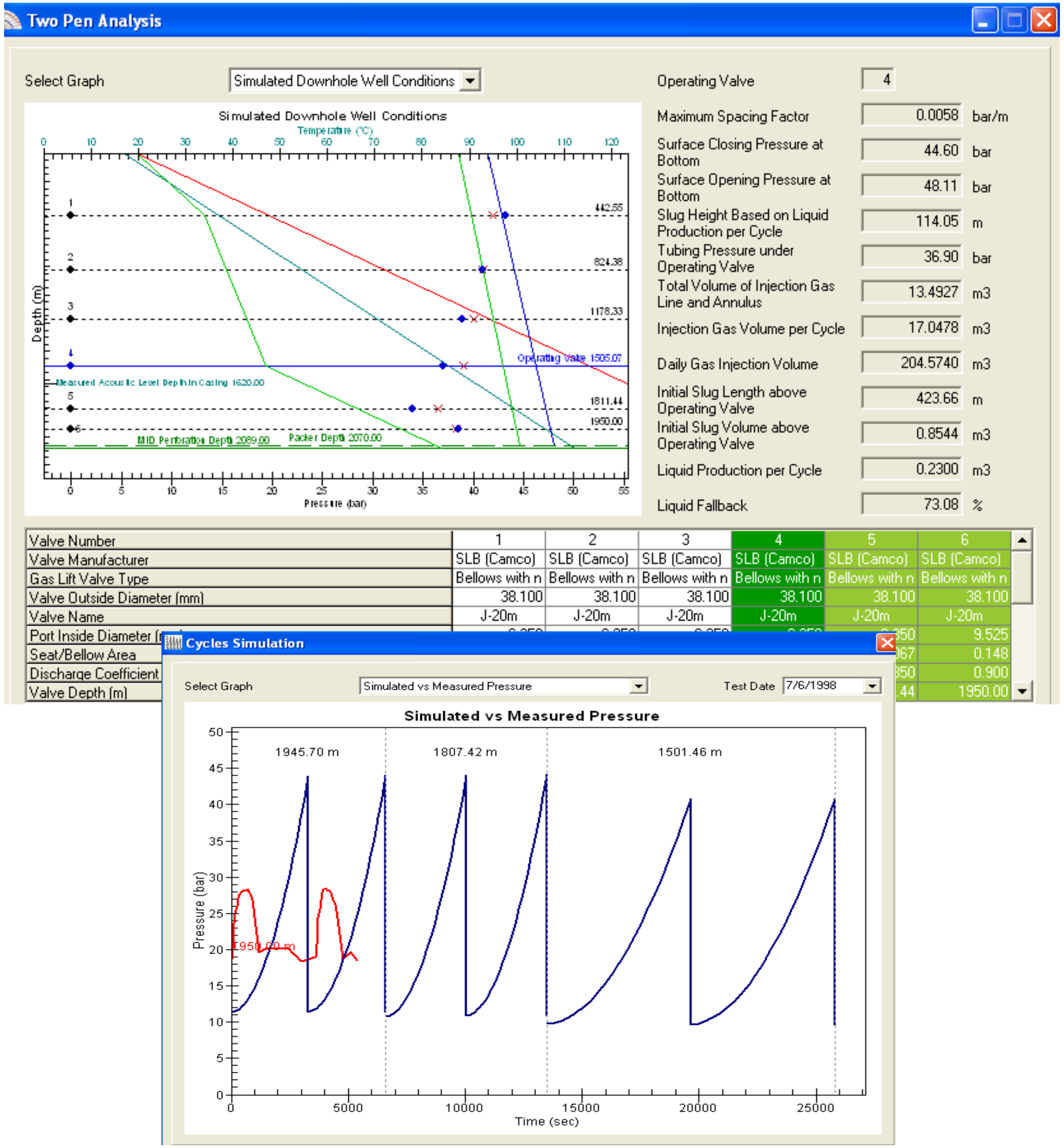


Valve Number	1	2	3	4	5	6
Valve Manufacturer	SLB (Camco)	SLB (Camco)	SLB (Camco)	SLB (Camco)	SLB (Camco)	SLB (Camco)
Gas Lift Valve Type	Bellows with n	Bellows with n	Bellows with n	Bellows with n	Bellows with n	Bellows with n
Valve Outside Diameter (mm)	38.100	38.100	38.100	38.100	38.100	38.100
Valve Name	J-20m	J-20m	J-20m	J-20m	J-20m	J-20m
Port Inside Diameter (mm)	6.350	6.350	6.350	6.350	6.350	9.525
Seat/Bellow Area	0.067	0.067	0.067	0.067	0.067	0.148
Discharge Coefficient	0.850	0.850	0.850	0.850	0.850	0.900
Valve Depth (m)	442.55	824.38	1178.33	1505.07	1811.44	1950.00

Glip

The main objectives of intermittent well trouble analysis are:

- Depth of operating gas lift valve
- Simulation of well conditions using minimal number of data
- Surface opening and closing pressure
- Gas injection data
- Eliminating requests for downhole pressure survey
- Defining optimal well operating parameters
- Comparison of data on pressure build-up with simulated data
- Increasing well production efficiency in intermittent gas lift wells.



Plunger design and simulation

The installations of the plungers not only increase the production, but sustain this increase over a long period. It has been observed in many cases, the rate of decline has actually changed, extending the life of the well dramatically. The basic questions that petroleum production engineers are faced when they intend to apply the plunger lift are:

1 - Is it possible makes a good well selection and where it should be applied?

2 - Is there enough pressure and gas volume?

3 - Will it run under a packer?

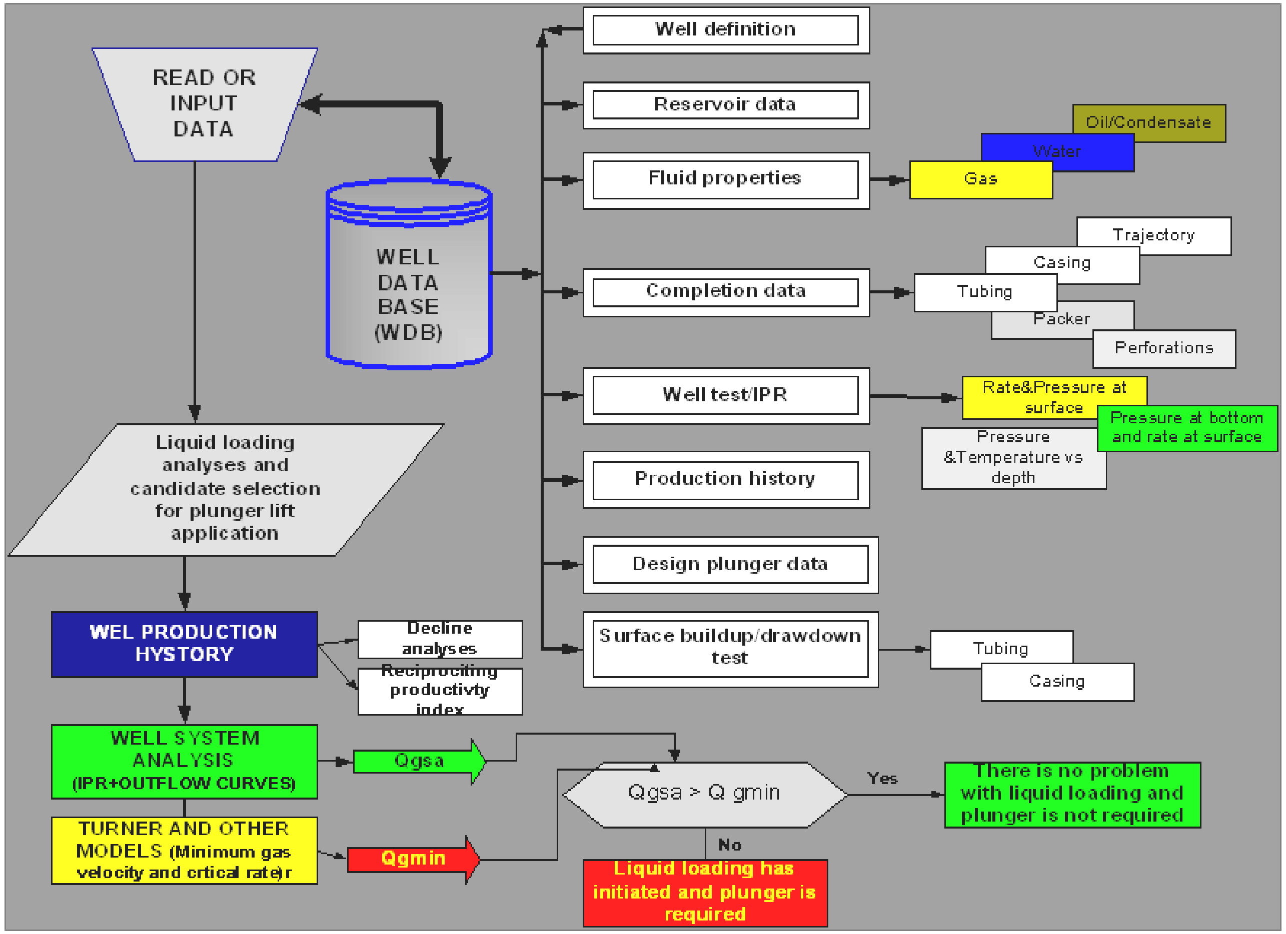
4 - Is sales line pressure too high?

5 - What are operating and maintenance costs?

6 - How long will it be effective?

7 - Will eventually need a pumping unit?

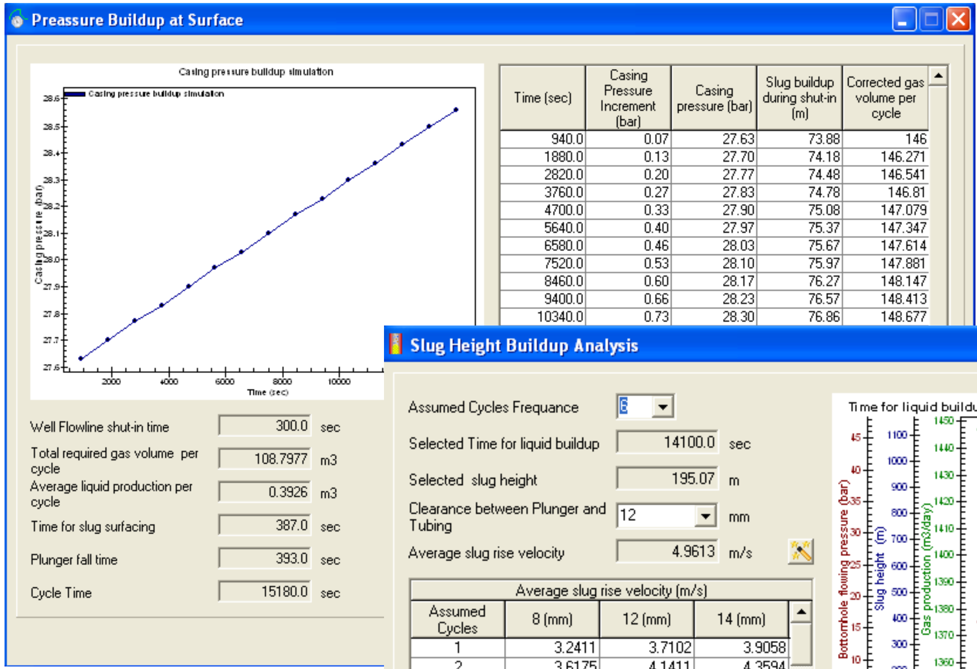
Knowing the answers to these questions give possibilities to identify the best candidates, operating cost and economics.

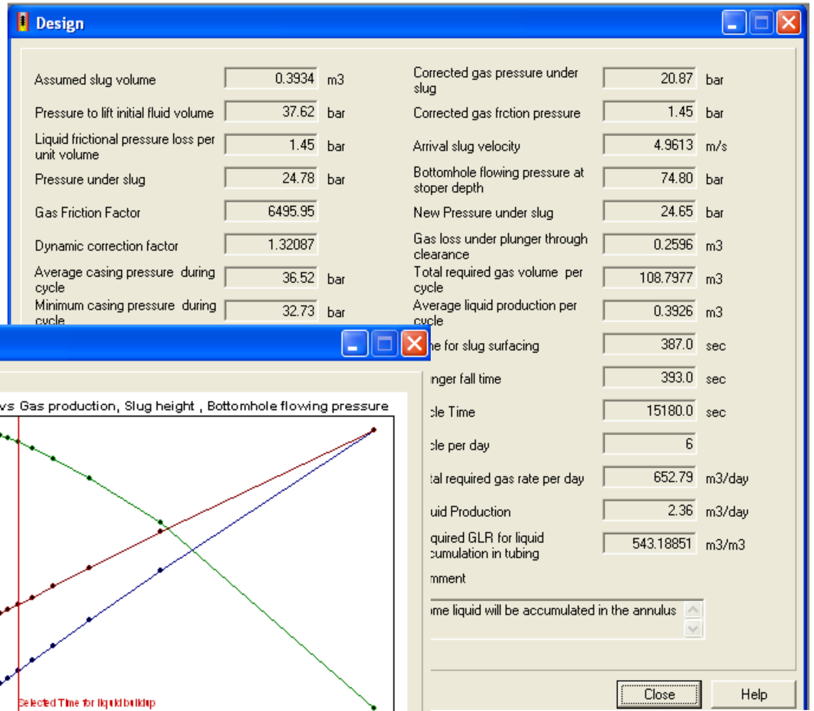


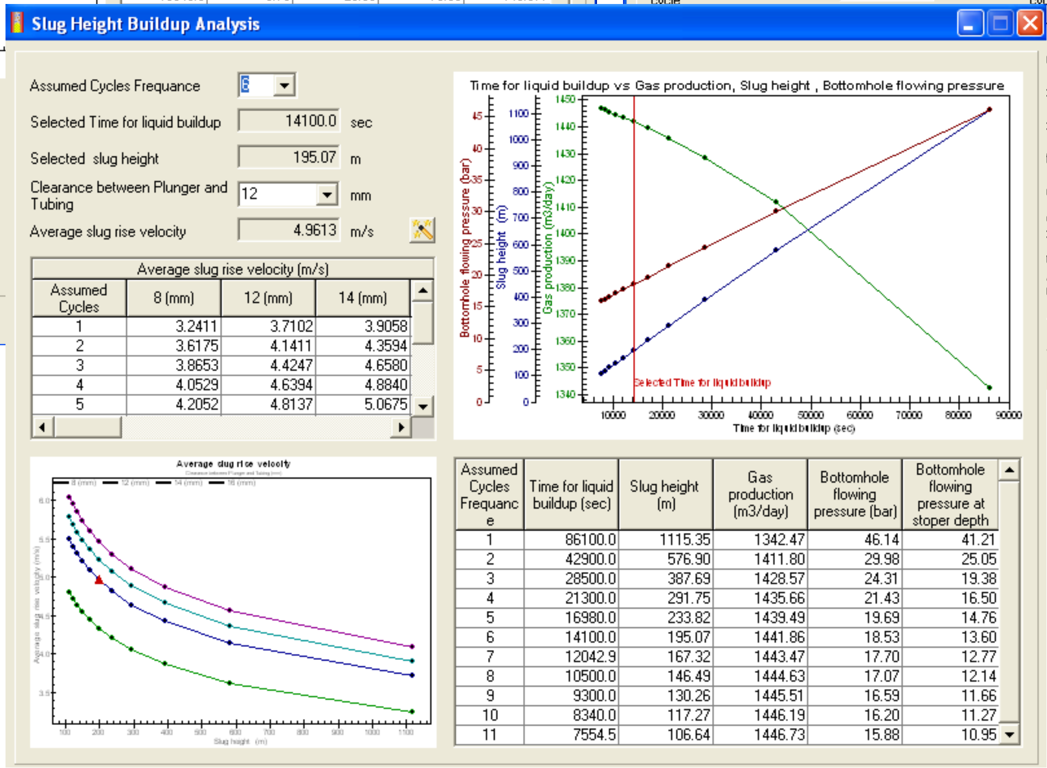
Glip

Plunger and slug velocity simulation / Slug buildup and cycles

Detailed plunger design







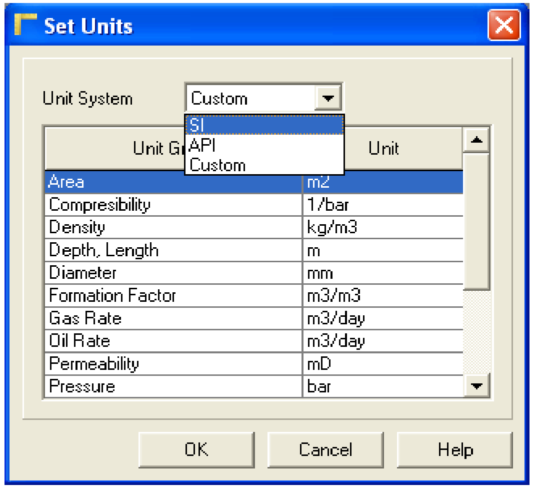
Casing pressure buildup simulation

Additional features

Unit conversion system

The built flexibility of the units system enables you to select any group of parameters and to select and define the unit of measurement. You can customize the units to suit your own personal preferences. By making selections from different categories, you can work in the units you prefer and save results in the units required by company police. GLIP offers a quick and simple conversion tool (API, SI, or customized).

If you do change units while running a session, they will remain changed permanently until you decide to change them back again.

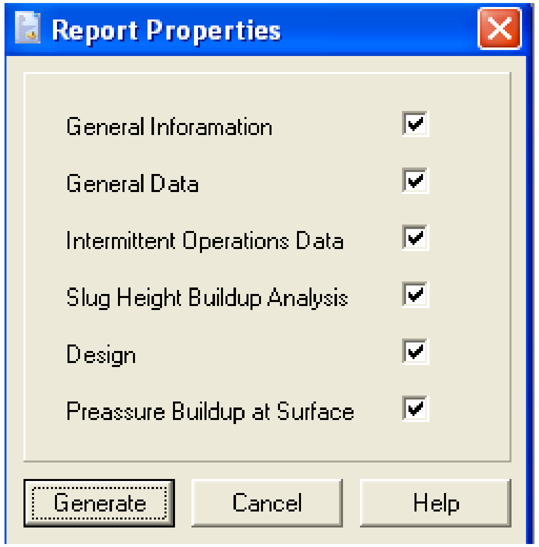


Languages

GLIP is a multilingual program. The working language (English, Spanish, and Serbian) can be changed on-line without any additional requirements. Also, every required report will be generated in selected language without interrupting the work with program.

Reports

The flexible architecture of software enables you to customize your request and to select which information and data you want to have in report. In each GLIP module you can customize report and generate it in HTML format. As already explained above, report(s) will be generated in the currently active language.



What is coming next?

- ***Include pattern recognition and neural network modeling***

  As intermittent operation is fully unsteady state process using predictive features of neural network tools, diagnosis capabilities of the model could be significantly improved. Recognition of typical two-pen chart shapes (casing and tubing pressures at surface)

- ***New research and test data to include slippage effect and fallback***

  Operating depth of gas entering, liquid fallback, plunger rising and falling velocity should be deeper investigated and include in model.

  Build physical model with real time monitoring to simulate different conditions on field.

- ***Software modifications***

  Connect real time data with expert model.

  Include new improved IPR model for gas condensate wells.

  Liquid loading prediction using decline analysis

  Simulation of chemicals injection for solving liquid loading

  Pumping systems (sucker road, progressive cavity and electrical submersible pumps)