TECHNICAL SPECIFICATIONS

PumaFlow®

Fluid Flow Simulation

Software Presentation

PumaFlow® is the all-in-one Beicip-Franlab's reservoir simulator, ranging from pilot simulation to Full Field prediction of Enhanced Oil Recovery.

This simulator is designed to improve up-front decision-making, allowing reservoir engineers to forecast a range of production scenarios based on different variables.

Functionalities and Algorithms

RESERVOIR DESCRIPTION

- Corner point geometry
- Block centered geometry:
  - Cartesian, Regular or with Local Grid Refinement
- Accurate computation of inter-cell connections
  - Faults (variable shifts, diagonal direction), local layers and interlayers, Pinch-outs

FLUID FLOW MODELING

- Based on Darcy's law for multiphase flow
  - Dynamic Kr-Pc data
  - J-Function model
  - Analytical computations for the 3-phase Kro (various models)
  - Hysteresis models
  - Interfacial tension effects
  - Wettability changes
  - Boundaries dealing with various flux conditions (Analytical aquifers, Lease-lines)
  - Diffusion/dispersion flux evaluation
  - Aquifer connection to matrix in Dual Medium
- Windowing (for sector models)
- Reference Pressure in Gas Phase for Gas-Water Systems

PRODUCTION ASPECT

A multi-level organization: perforation, well, sector, reservoir, field.

- Well-reservoir relationship based on Darcy's law (or quadratic law for gas)
- Working conditions based on flow rates, pressures (bottom-hole and surface) and ratios
- Layer flow rate distribution including possible cross-flow in the well-bore
- Pressure drops in the tubing calculated from tables or analytical laws
- Improved PI calculation
- Monitoring of injection/production rates (automatic reinjection)
- Highly flexible algorithm for Gas-lift optimization
- Various monitoring operations for all the production levels
- ECLIPSE schedule importer
  - New Keywords and/or argument supported
  - Reporting tool for schedule import
- Generic schedule import for automatic prediction constraints generation
- Generic cycle definition for WAG, Huff & Puff, chemical slugs...

BLACK OIL

- Black-oil representation with an extension characterized by a pressure dependent gas gravity
- Real two-component formulation for slightly volatile oils condensate gas applications.
- Precise and flexible input of composite PVT data for flow rate calculation at surface conditions.
- Variable salinity by solving ion transport equations
- Miscible gas (Todd&Longstaff mixing parameter)
- API tracking
- SWATINIT

COMPOSITIONAL

- N-components in all phases
- Two-parameter equations of state (PR, SRK)
- LBC formulation
- Tabulated or analytical K values function of pressure, temperature and composition
- Dynamic definition of surface equipment (separators, gas plants) working under various conditions
- Automatic gas cycling
- Gas dissolution in water and/or in oil (swelling effect)
- Post-treatment hydrocarbon tracking (cloning methodology)
- Compactness

FRACTURED RESERVOIRS

- Fractured and non-fractured zones in the same reservoir
  - Single or dual permeability
- Matrix-fracture flow characterized by:
  - Matrix block dimensions
  - Specific relative permeability functions
- Physical phenomena with several degrees of complexity:
  - Capillary forces, gravity effects, viscous forces
  - Diffusion flux between the two media
  - Gas adsorption on the rock defined by a Langmuir isotherm (shale-gas)
- New reference pressure (Shale gas)

INTELLIGENT COMPLETION DEVICES OPTION

- ICD Design : large databank from main providers
- Black-oil and compositional contexts
- Discharge coefficient in the ICD = f(Reynolds number)

THERMAL EOR OPTIONS

- Available in both Black Oil and compositional context
  - Cooling (warming) effects
  - Steam injection (Huff&Puff, SAGD with steam trap control)
  - Well formation heating
  - KrPc, PVT, Rock : Temperature and pressure dependent rock and PVT properties
  - Triphasic flash: adding of vaporization and dissolution phenomena
  - Specific well heat losses
  - Specific heat losses at the burdens
  - Additional thermodynamic models (specific correlations)

CHEMICAL EOR OPTIONS

- Single Well Chemical Tracer Test
- Approached Low Salinity formulation
- Diffusion/Dispersion of chemical additives
- Compatibility in dual-medium: unique matrix-fracture exchange function allowing fine tuning on the sharing of chemical agent

BeicipFranlab

- **Polymer:** dedicated to both polymer flooding and water shut-off treatment applications.
  - Time-dependent water phase mobility reduction (function of polymer concentration, salinity, temperature, permeability reduction factor (in case of adsorption) and shearing stress)
  - Variable and dynamic saturation end-points
  - Reversible/irreversible adsorption (salinity, porosity and permeability-dependent)
  - Mobility correction of the rear front following the polymer slug
  - Inaccessible pore volume fraction for polymer solutions
  - Thermal impact on adsorption, mobility reduction and polymer degradation
  - Multi polymers injection
- **Surfactant**
  - Impact on water-oil interfacial tension (function of salinity and alkaline concentration if injected)
  - Impact on Kr-Pc curves via the IFT-dependent Capillary Number
  - Salinity-dependent adsorption (also pH-dependent in presence of alkaline additive)
- **Alkaline**
  - Impact on water-oil interfacial tension (function of salinity and alkaline concentration if injected)
  - Impact on Kr-Pc curves via the IFT-dependent Capillary Number;
  - Water phase pH modeling (related to the alkaline type and the OH- rock adsorption)
- **Foam**
  - Transported in the aqueous phase
  - Impact on the gas mobility
  - Adsorption on the rock (reversible)
  - Impact on the water-gas interfacial tension
  - Decay with time (according to a kinetics specified via a given half-life time)

CO2 EOR OPTION

- Swelling effect
- Gas dissolution in water

GEOMECHANICS OPTIONS

- Dual-medium context (matrix-matrix and fracture-fracture exchanges)
- Absolute permeabilities pressure and/or temperature dependent
- Estimation of in-situ effective stresses (using the Rankine and the Mohr-Coulomb criteria)
- Rock thermal expansion: porosity can now be temperature dependent
- Rock absolute permeability dependent on pressure and temperature

PARALLEL AND NUMERICAL OPTIONS

- Cluster technology both on Linux and Windows (Open MP or MPI parallel computing)
- High efficiency solvers (best-in-class for performances and robustness for large to super-large grids)
- Various numerical criteria (numerical scheme, outer iteration control, time step management, linear system resolution)
- Several degrees of implicitness of the source terms, from explicit to a fully coupled formulation

Results Analysis

A modern reservoir engineering environment:

- Histograms
- Cross-plots and graphs (Filters and graphic settings)
- 2D/3D viewers
- Cross-sections
- Posted views
- Templates

Data Management

A UNIFIED DATAMODEL

- Starting from reservoir description to final results analysis with the benefits of the OpenFlowSuite platform
- Stored in a relational database allowing multiusers management and secured transactions.

IMPORT/CREATION

- 3D CPG, radial or cartesian geometry and grid properties (in GRDECL and PumaFlow keywords format)
- FIP/AFIP regions
- Connections (inter-cell connection, Non-Neighbor Connections, faults)
- Zone of interest
- Aquifers (including Carter-Tracy and Fetkovich)
- Burdens
- KrPc
- PVT
- Traps
- Rock model
- Dual medium model
- Well paths and logs (in ASCII, LAS 2.0 and 3.0)
- Well dynamic data production/injection history, RFT/PLT, well tests (in ASCII and OFM)
- Well pressure and perforation data (in ASCII)
- VFP tables (for condensate gas too)
- Remedial operations
- Also ability to directly share with Petrel, using an Ocean plug-in, grids and properties, well data
- Optimized MPI set from flowmeters
- End Point Scaling on Zones of Interest
- LGR in 3D view
- Alkaline/Surfactant/Polymer and Foaming Agent
- Water-Oil and Water-Gas Interfacial Tension Tables
- ResQML 2.0 import
- Data exchange between OpenFlow Suite projects

Extensions and Customization

- Script language with Groovy
- PVT package available: **PVTFlow™**

Fluid definition & analysis:
- Triphasic flash
- Phase envelope
- Lumping
- Regression
- *Extrapolation & Split*

From simple to complex fluid definition activities:
- CCD, CVD, Differential
- Mixer
- Separator
- Compositional Gradient
- Minimum Miscibility Pressure
- Quick Black Oil PVT generation

- Advanced Surface Network: PumaFlow®-Gap link
- FracaFlow®/CougarFlow® link

System Requirements

- **Operating Systems**:
  - Supported on Windows 10, Compatible with Windows 11
  - Linux Red Hat 7 and Red Hat 8 for calculators only (unavailable GUI)
- **RAM**: 48 Gb or more recommended, 32Gb minimum
- **Minimum free disk space**: 5 Gb (for installation files)
- **CPU**: x86-64 processors (Opteron, CoreDuo, Core2Duo, Xeon & EMT64, Nehalem, Westmere, Sandy Bridge, Core i3, i5, i7)
- **Dualcore or Quadcore**: 2 GHz or more recommended
- **Graphics board**: NVIDIA (except Quadro FX 1000, Quadro FX 3500, Quadro NVS 110 M, Quadro NVS 280 SD and NVS 300) with recent driver (at least OpenGL 3.3 -driver 330 or later)
- Openmotif rpm package must be installed on Linux
- **Database**: MySQL 5.5, 5.6.X (with X superior to 22), 5.7 or 8.0 and Oracle 12c, 18c or 19c
- FlexLM 11.16.2 server for licensing

Beicip-Franlab Headquarters
232, avenue Napoléon Bonaparte
92500 Rueil-Malmaison - France
Tel.: 33 1 47 08 80 00
Email: info@beicip.com

BeicipFranlab
An IFP group company