CYDAR new functionalities

These new fonctionalities are inclued in the two-phase flow module

Electrical Measurements

This new functionality uses electrical measurements from local electrodes inside the rubber sleeve. Electrical current is established along the sample and potential are measured on the electrodes.

Electrical mesurements have two applications :

1. Measurement of saturation profiles along the sample

The average water saturation between electrodes can be estimated from the resistivity index (RI) using empirical laws.

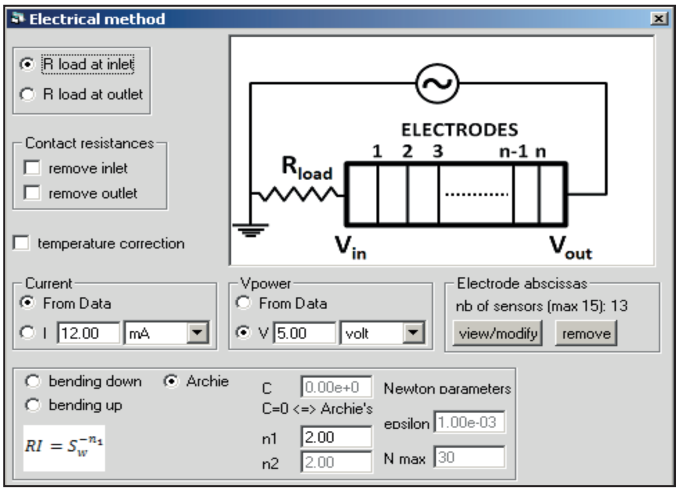
> Three models have been implemented: Archie's law, "Bending down" and "Bending Up" from Fleury SCA 2003-31.

> The Inputs are voltages measured along the plug.

2. Determination of resistivity index from displacement experiments

This technique is much faster than the porous plate method.

> Uses CYDAR numerical simulation and optimization to determine saturation profile.



Parameter inputs for electrical measurements.

Inertial correction in Two-Phase flow

In the two-phase flow module, this functionality allows inertial corrections (Forchheimer) for gas injection at high flow rates. For high flow rate, inertial effects reduce the section of passage of the fluid through the pores, and the "apparent" permeability decreases as the velocity increases. This effect is more pronounced for high permeability and gas.

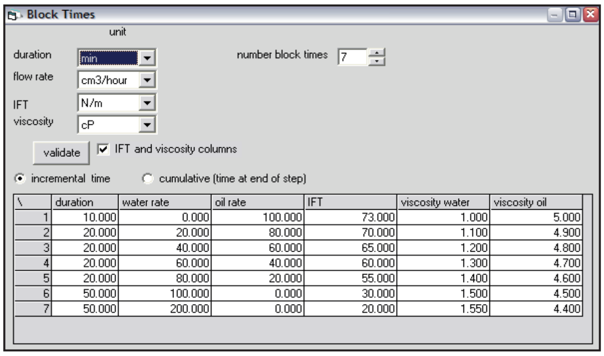
Two-Phase flow with Simplified EOR

This functionality allows a simplified simulation of polymer or surfactant injection during a two-phase flow experiment. The purpose is to simulate a waterflood (imbibition) followed by injection of a surfactant or a polymer. Low surface tension or high viscosity increases the viscous forces compared to capillary forces, and reduces the capillary end-effect. The change of fluid properties at end of simulation allows the quantification of recovery due to this effect.

> Viscosities and interfacial tension can be changed for each block time.

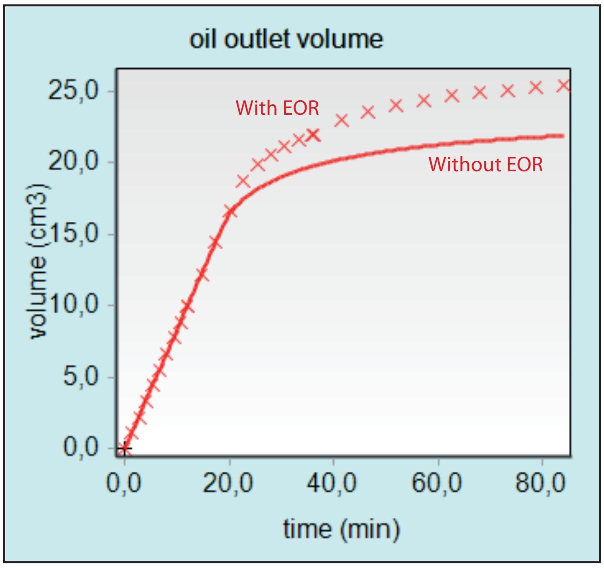
> The capillary pressure is calculated from the interfacial tension using J-Leverett function.

> However, mixing in the aqueous phase is not taken into account.



\	duration	water rate	oil rate	IFT	viscosity water	viscosity oil
1	10.000	0.000	100.000	73.000	1.000	5.000
2	20.000	20.000	80.000	70.000	1.100	4.900
3	20.000	40.000	60.000	65.000	1.200	4.800
4	20.000	60.000	40.000	60.000	1.300	4.700
5	20.000	80.000	20.000	55.000	1.400	4.600
6	50.000	100.000	0.000	30.000	1.500	4.500
7	50.000	200.000	0.000	20.000	1.550	4.400

Block times with Simplified EOR inputs.



Influence of EOR on oil production.

CYDAR new modules

Two-Phase Flow with EOR module

In CYDAR 2017, we are introducing a new Two-Phase flow module with EOR (Enhanced Oil Recovery), to simulate the effects of polymers and surfactants on Two-Phase Flow experiments.

The EOR module simulates:

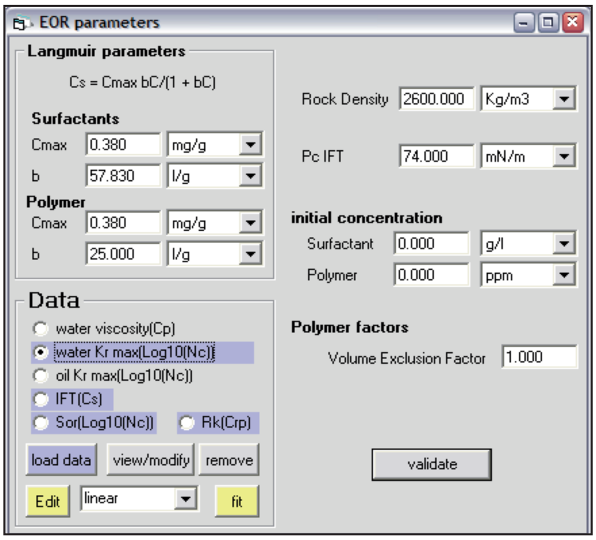
> Injection of polymers and surfactants.

> Mixing in the aqueous phase at each simulation step: calculation of the new concentrations; calculation of the new flow properties (viscosity, capillary pressure Pc, relative permeabilities Kr).

> Effect of polymers on water viscosity, water permeability, and volume exclusion.

> Effect of surfactants on capillary pressure, Kr_{MAX}, and Sor.

> Adsorption for polymers and surfactants, Langmuir isotherm.



Parameter entries for EOR simulations.

Physical models included in EOR simulations:

> **Effects of polymers:** reduce the aqueous phase mobility and the mobility ratio with the other phase. Polymers lead to water viscosity increase, water permeability reduction, and volume exclusion.

> **Effects of surfactants:** Surfactants reduce the interfacial tension (IFT), capillary pressure Pc, the capillary number Nc and residual oil saturation Sor. Surfactant have also an impact on relative permeability.

> **Adsorption:** simulated as Langmuir adsorption.

> **Mass balance equation:** mass balance equations for the two fluids, and mass balance equation for each chemical species.

Input parameters for EOR simulations:

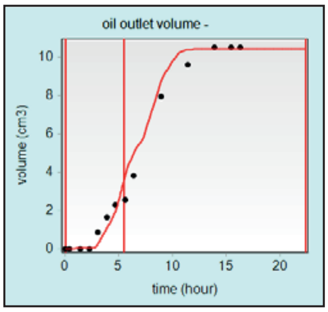
> **Data:** Water viscosity as a function of polymer concentration; IFT tabulated according to surfactant concentration; Water and oil Kr_{MAX} and Sor; reduction factor of the permeability to water Rk tabulated according to the mass fraction of adsorbed concentration.

> **Langmuir parameters:** C_{MAX} and b for polymer and surfactant.

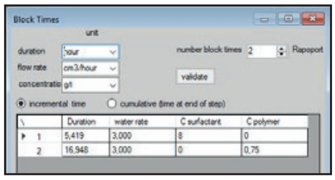
> **Rock density** to account for the adsorption.

> **IFT** corresponding to the Pc without chemicals.

> **Initial concentration** in the core for surfactant and polymer.



Comparison between measurements (dots) and simulation, using data from Dourache et al. OGST, 67, 2012.



Block times entries for the injected concentration.

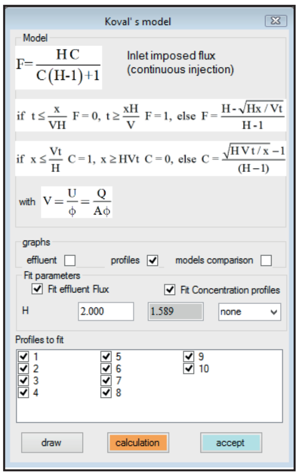
Dispersion / Tracer module

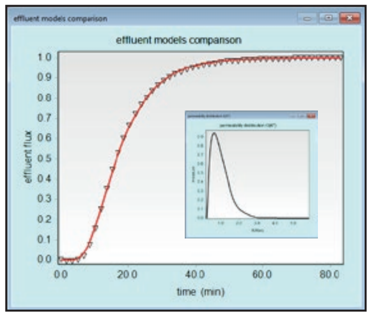
In CYDAR 2017, we are introducing a new dispersion / tracer module.

Dispersion experiments give indication on the homogeneity of the sample, by analysing dispersion of an injected solution at concentration C_{in} with a solution at concentration C_0 present in sample.

> 4 models have been implemented: Classical, Koval, Coats and Smith, and Stratified.

> Temperature corrections and normalization are available.





Example of dispersion experiments interpreted using the standard dispersion model (in red) and the stratified model (insert) described in paper SCA2015-014.

CYDAREX