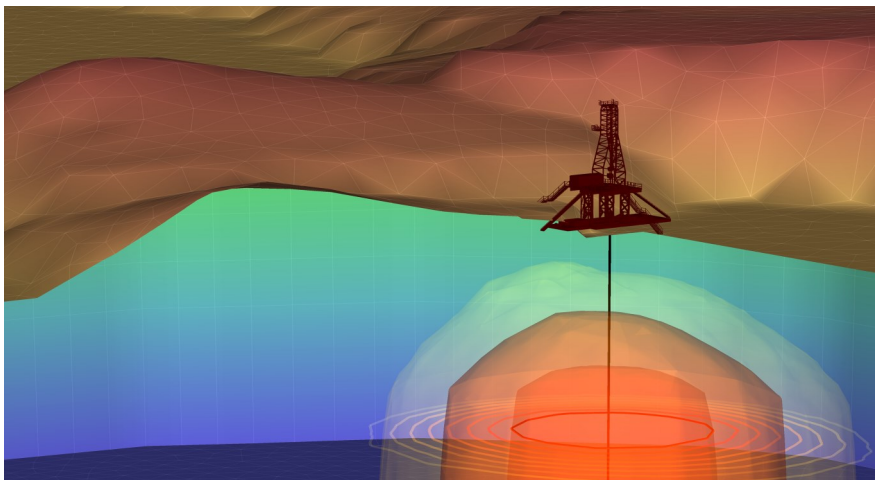
FEFLOW

Modelling geothermal energy and heat transport processes

With the rapid growth of the geothermal energy market, simulation models for heat transport have evolved from an exotic exercise to a standard application during the last decade. FEFLOW's ability to model all relevant components of heat transport processes combined with its flexible meshing strategies have made FEFLOW an industry standard for geothermal modelling.

APPLICATIONS

- Near surface geothermal installations
- Deep geothermal installations
- Open and closed loop systems
- Borehole heat exchangers (BHE)
- Heat exchanger arrays
- Aquifer thermal energy storage (ATES)
- Heat transport in porous and fractured media under saturated and unsaturated conditions
- Interaction with heating and cooling installations



Visualisation of a heat plume in 3D.

BENEFITS

- Efficient and precise simulation of geothermal installations
- Support for open-loop and closed-loop systems
- Calculation of the influence of groundwater flow
- Interaction of neighbouring installations
- Decision support for resource management

FEATURES

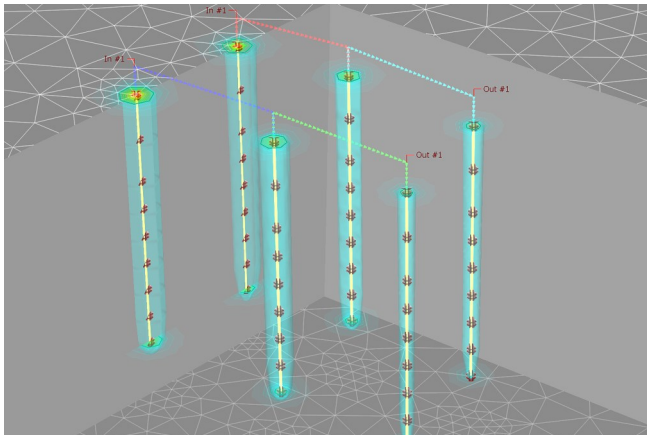
- Advection-conduction/dispersion heat transport
- Free, forced and mixed convection
- Fracture flow and fracture heat transport
- Thermohaline convection
- Coupled density dependent simulation for varying temperature and/or brine concentrations
- Linear or nonlinear temperature-density relationship
- Predefined or user defined temperature-viscosity relationship
- Variable density flow in both porous and fracture media
- Saturated and unsaturated porous media
- Borehole heat exchangers (BHE)
- Heat exchanger arrays
- Open loop systems

PHYSICAL PROCESSES

To model geothermal energy systems, multiple interlinked physical processes in the subsurface need to be accounted for simultaneously. FEFLOW considers all relevant processes from advective, conductive and dispersive heat transport to temperature-related fluid density and viscosity in deep aquifers as well as under variably saturated conditions in the vadose zone.

NEAR SURFACE GEOTHERMAL ENERGY

The thermal storage capacity of shallow aquifers and aquitards is a valuable resource for the heating and cooling of buildings and facilities. FEFLOW simulations covering both the unsaturated zone and underlying aquifer(s) can provide essential information for evaluating system feasibility, for deciding on the system design and for assessing environmental impacts.



Borehole heat exchanger arrays.

DEEP GEOTHERMAL ENERGY

Driven by the growing use of geothermal energy from deep geological structures for power plants and district heating, there is increasing demand for detailed simulations to estimate energy yield, lifetime and potential impacts on the environment and on adjoining installations, with the overall goal to maximize profitability. FEFLOW provides the tools to model all relevant aspects of deep geothermal systems.

OPEN LOOP SYSTEMS

Open loop systems, consisting of at least one pair of extraction/injection wells, are commonly used for cooling or heating of large apartment buildings, industrial facilities and for electrical power generation. Providing input for design and optimisation of such well systems is a standard FEFLOW application.

CLOSED LOOP SYSTEMS

Closed loop systems such as borehole heat exchangers can be modelled on different levels of detail, ranging from considering the heat source or sink only via a specific BHE boundary condition to fully discretised solutions. These approaches cover all kinds of applications from large scale regional models to design studies for new types of BHE.

For many practical cases the BHE boundary condition provides the best option, combining a very precise representation of the BHE with a high level of numerical efficiency and a straightforward handling in the FEFLOW user interface. BHE boundary conditions allow the direct definition of constant or time varying inlet temperature as well as power or temperature differential.

Applying the BHE boundary condition, BHEs can also be combined into arrays, prescribing refrigerant and heat flow only at the array inlet and outlet. Large numbers of BHE and their properties can directly be imported from map files.

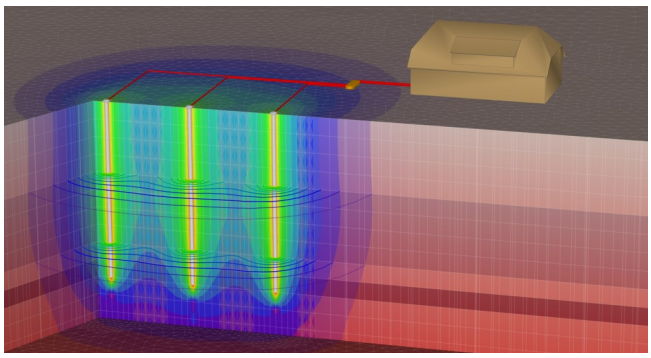
UP-TO-DATE VISUALISATION TOOLS

FEFLOW's generally cutting edge visualisation encompasses the following tools specifically for geothermal simulations:

- Chart windows to monitor the temperature development of individual BHE elements
- Array connections in 2D/3D view windows
- Real and virtual BHE radius in addition to the ideal distance to neighbouring nodes

EXTENSIBILITY - OPEN PROGRAMMING INTERFACE

Most process parameters can easily be accessed and modified during a simulation via the FEFLOW interface manager (IFM). Typical applications include the implementation of additional physical processes, control of boundary conditions and coupling to external algorithms or models - such as for heating systems in buildings.



Borehole heat exchangers in parallel connection.

Contact us: MIKE Powered by DHI Client Care - mike@dhigroup.com
For more information visit: www.mikepoweredbydhi.com