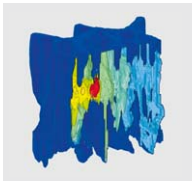
dynardo
dynamic software & engineering

GEOTHERMAL POWER PLANTS

Dynardo provides an efficient simulator for hydraulic fracturing as a software basis for optimal generation and operation of heat exchangers of large petro-thermal power plants.



Optimization Task

In petro-thermal power plants, deep rock layers with temperatures up to 200 ° C are used for energy production by injection of water. Besides the efficient production of the drill hole, the generation of the heat exchanger and the assurance of its sufficient permeability in deep rock layers is one of the main challenges of the geothermal energy industry.

For the generation of the heat exchanger, the so-called hydraulic fracturing (fracking), a method known from the gas industry, is used to stimulate natural gas reservoirs. By means of water pressure, the rock formation between two bore-hole endings is stimulated to generate a sufficient permeability for the heat exchanger. The initiated joint system has to maintain its sufficient permeability for a long period of time even under operating pressure and stress state of the regenerating rock layers in order to ensure a trouble-free operation. A sufficient ability of prognosis is necessary to calculate the process of hydraulic fracturing and the evolution of permeability in operation and to optimize the location of the bore-hole and the hydraulic stimulation. So far, there has been no powerful commercial software program for this purpose that could determine the formation of cracks in a three-dimensional model and the degradation of the rock's permeability under operating conditions in jointed rock layers.

"It is recommended to use hydraulic stimulation. Controlling and optimizing the stimulated fracture network is recommended to control the costs of stimulation and production. The development of a 3D fracture diagnostic tool is necessary to optimize stimulation techniques".

Quote from the report 2007 of the US renewable energy project

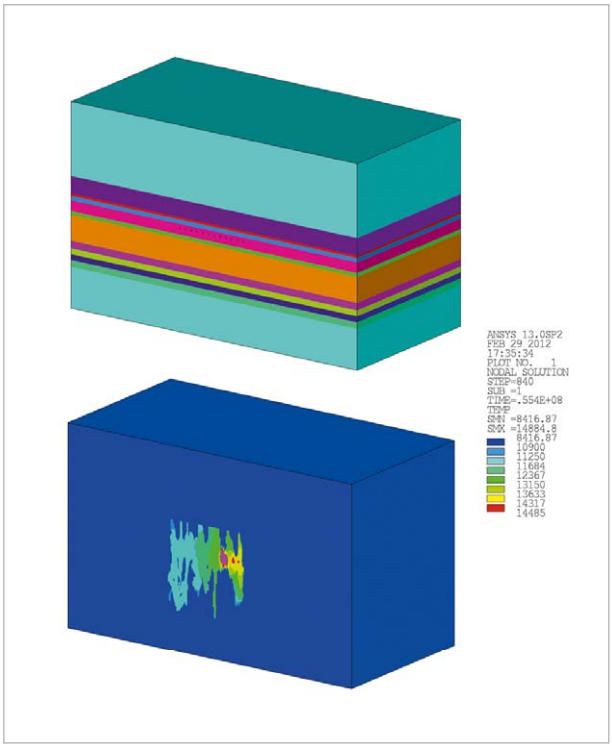
Solution Methodology

ANSYS/multiPlas/optiSLang® - Simulator

Today, Dynardo is the only engineering service company that can calculate the process of hydraulic fracturing in natural gas reservoirs within 3-dimensional finite element calculations with sufficient feasibility prognosis and in accordance to measurements. This is achieved by combining ANSYS, one of the most powerful FEM programs, with Dynardo's software components multiPlas - Material Library for geotechnics - and optiSLang - Software for model calibration and optimization. The sufficient accuracy of calculation and visualization of the major mechanisms leading to a hydraulic fracking network is crucial for a forecasting simulation model.

Currently, in a research project about calculation of the permeability degradation under operating conditons, the simulation capabilities have been extended and adjusted for the conditions of the geothermal energy industry.

ANSYS multiPlas optiSLang®



3D coupled thermal-hydraulic-mechanical FEM simulation of hydraulic fracturing

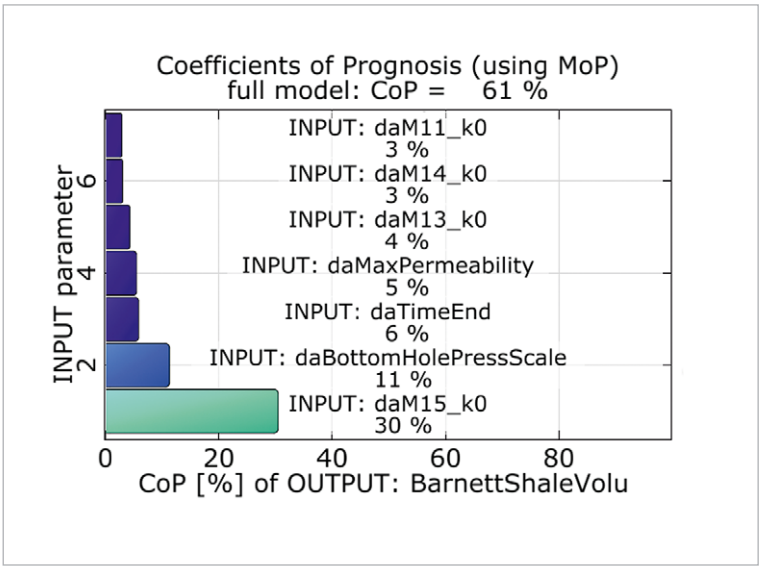
For the calculation and optimization of the heat exchanger, it is essential to determine those parameters and mechanisms which influence the process of fracturing the most and to compare them with the measurements. After a successful matching, the simulator for the reservoir can be developed. The calibrated model is used to optimize the heat exchanger. In order to use the simulator, a parametric modeling in the homogenized volume model is necessary. Because it might be necessary to exercise hundreds of calculations for the validation, calibration and optimization, the calculation of a hydraulic stimulation and its operation must be extremely efficient. ANSYS is used for parametric modeling as well as efficient calculation.

In a second step, Dynardo's material library multiPlas calculates the process of fracturing within the rock and its joint system in the homogenized volume model. The non-linear analysis of the load history starts with the tension and pore water pressure initialization. The hydraulic fracturing was analyzed by performing a coupled hydraulic-mechanical calculation. The coupling is realized using the flow forces determined by the difference in the pore water pressure taken from the hydraulic calculation as well as the change in permeability due to fracturing from the mechanical calculation.

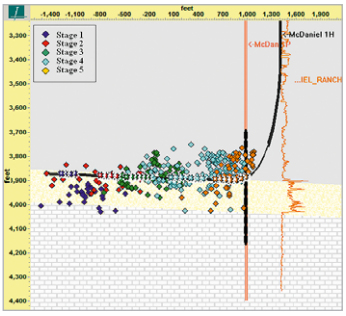
The third important component is Dynardo's optiSLang. The software is used to validate and calibrate the reservoir model as well as to optimize the heat exchanger.

Customer Benefits

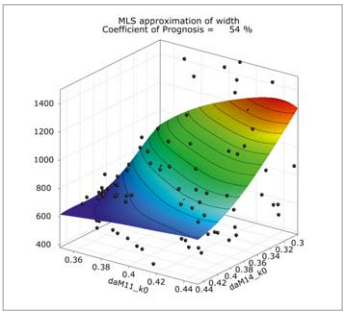
- Simulation of the heat exchanger generation by hydraulic fracturing
- Simulation of permeability and fracturing evolution under operating conditions and different stress states of the regenerating rock layers



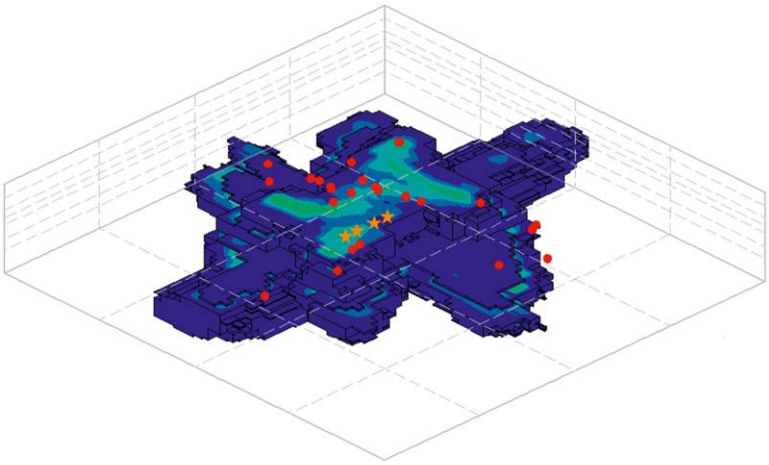
Identification of important uncertainties in the formation and important parameters of stimulation



Comparison of simulation with measurements (Microseismic)



Metamodel of Optimal Prognosis (MOP)



Stimulated rock body after 193 minutes compressive stress (blue=simulated/red=measured)

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