Graduation project

VISUALIZING HEAT TRANSFER IN GEOTHERMAL RESERVOIRS

Description Geothermal energy from hot rock layers inside the Earth's crust is a promising sustainable energy source. Heat recovery takes place by circulation of a production fluid into the (man-made) fracture network inside the geothermal reservoir (Fig. 1; top). However, the thermal interaction between cold production fluid and hot rock is highly non-trivial due to the complex geometry of the fracture network (Fig. 1; bottom). Hence, determining the most effective flow for optimal heat recovery remains a big challenge. Topic of the graduation project is gaining a deeper understanding of this thermal interaction.

Goal and approach The thermal interaction is to be investigated by *direct* visualization of the paths by which heat transfer takes place. These "thermal paths" are the thermal analogies to streamlines and thus enable heat-transfer visualization in the same way as streamlines enable flow visualization.[1] Crucial is that this method admits heat-transfer visualization throughout the *entire* reservoir, i.e. in both fractures and rock, and thus offers insight into the way heat flows from the hot rock to the production fluid at a far more fundamental level than conventional methods based on temperature. The general research plan is as follows:

- Numerical simulation of velocity and temperature field in a representative 2D fracture network by way of a commercial flow solver (e.g. `FLUENT` or `COMSOL`).
- Development of dedicated data-processing algorithms for the construction of the thermal paths in the *entire* reservoir from the simulated velocity and temperature fields by e.g. the post-processing functionality of `FLUENT` or `COMSOL` and/or with `MATLAB`.
- Thermal reservoir engineering by way of the thermal-path methodology:
  - Visualization of the thermal interaction between production fluid and hot rock.
  - Determination of the thermal-path configurations for optimal heat recovery.
  - Manipulation of the thermal-path configurations via the inlet flow conditions.

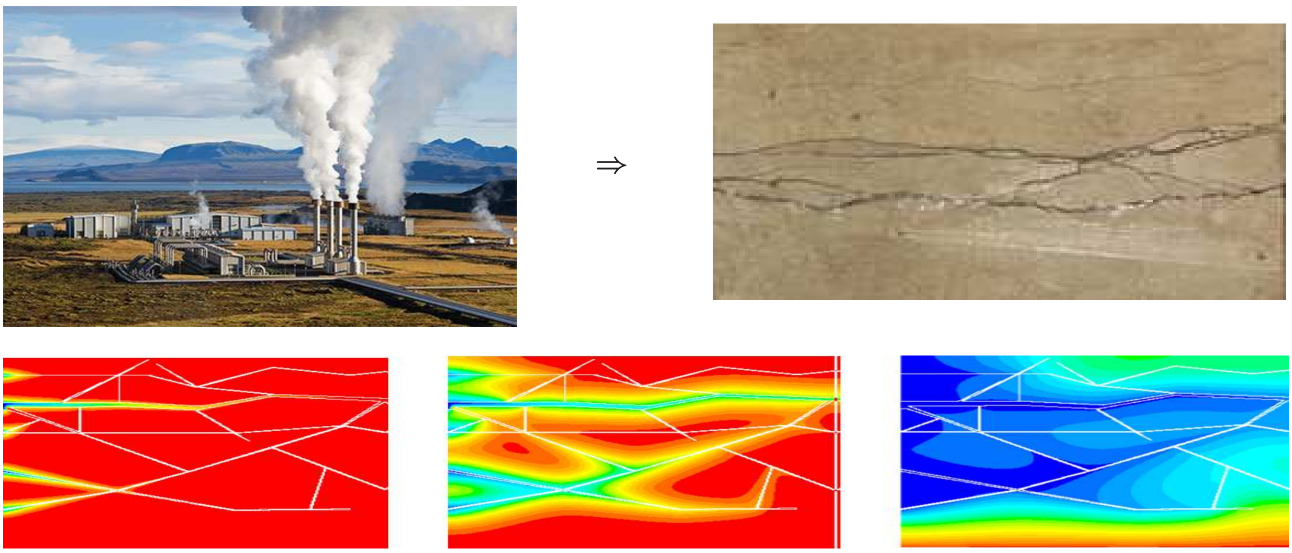

Figure 1: *Geothermal plant and close-up of typical underground fracture network (top); typical thermal interaction between cold production fluid and hot rock (bottom).*

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[1] M.F.M. Speetjens, A generalised Lagrangian formalism for thermal analysis of laminar convective heat transfer, Int. J. Thermal Sci. 61, 79-93 (2012)