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Mixed finite element approximation of a coupled reservoir-wellbore model with heat transfer

In order to interpret recorded temperatures in wellbores as well as a flowrate history at the surface and thus to better characterize reservoirs, we are interested in the thermomechanical coupling of a petroleum reservoir with a vertical wellbore, both written in 2D axisymmetric form.

The reservoir model, assumed to be a monophasic multi-layered porous medium, is described by a Darcy–Forchheimer equation together with a non-standard energy balance. The wellbore model is based on the compressible Navier–Stokes equations and an energy equation. The coupling between these two models is achieved by adequate transmission conditions at the perforations.

We obtain, at each time step, a mixed formulation and the uniqueness of the solution is established by means of a generalization of the Babuska–Brezzi theorem.

Concerning the spatial discretization, we approximate the heat and mass fluxes by the lowest-order Raviart–Thomas mixed elements, the pressure and the temperature by piecewise constant elements, the fluid's velocity by Q_1 continuous elements while the Lagrange multipliers on the interface are taken piecewise constant. The density is updated by means of a thermodynamic module and the convective terms are treated by appropriated upwind schemes. A technical analysis of the discrete mixed formulation is carried on and the well-posedness of the problem is proved.

Numerical tests including real cases will be presented.