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A finite element formulation for non-Newtonian fluid flow through cracked, deformable porous media

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Non-Newtonian fluid flow through deformable porous materials is important in several common situations: for instance blood flow through the human body or flow of oil through fractured porous materials.

In order to accurately simulate these flows in the presence of cracks, a finite element formulation for non-Newtonian power-law fluids based on the generalized Darcy's law [1] [2] is derived. This formulation is appended with a subgrid model to include the effects of non-Newtonian fluid flow through cracks, formulated in a similar manner as was done by [3] for Newtonian fluids. This formulation was compared with several analytical and numerical solutions for Newtonian fluids and verified for non-Newtonian fluids with results from the built-in MATLAB solver.

The resulting code was used to simulate some typical boundary value problems. The results of this show the influence of the non-Newtonian behaviour on the pressure distribution in the fluid and deformations of the porous material.

References

[1] Vittorio Di Federico, Marco Pinelli, and Rita Ugarelli. Estimates of effective permeability for non-Newtonian fluid flow in randomly heterogeneous porous media. *Stochastic Environmental Research and Risk Assessment*, 24(7):1067–1076, 2010.

[2] T. Al-Fariss and K. L. Pinder. Flow through porous media of a shear-thinning liquid with yield stress. *The Canadian Journal of Chemical Engineering*, 65(3):391–405, 1987.

[3] René de Borst, Julien Réthoré, and Marie-Angèle Abellan. A numerical approach for arbitrary cracks in a fluid-saturated medium. *Archive of Applied Mechanics*, 75(10-12):595–606, 2006.