Contribution ID: **89** Type: **Oral Presentation**

Adaptive models for nonlinear flows in highly heterogeneous porous media

Monday, 22 May 2023 14:30 (15 minutes)

Underground storage of gas (H2, CO2, etc.) and geothermal energy has become a major research area in the ongoing energy transition. In this context, it is important to model and simulate single- and multiphase flows in highly heterogeneous porous media, characterized by very irregularly distributed permeability profiles featuring fractures, channels and macropores.

Flows in these media might not follow Darcy's law; Forchheimer's quadratic law is more adequate in the high-Reynolds zones, and applying it globally in the domain is very accurate but costly numerically because of the nonlinearity introduced. Instead, keeping Forchheimer's law only where necessary should improve computing cost without losing much accuracy. The difficulty with coupling the two laws lies in determining which regions of the porous medium require Forchheimer's model and which ones can be treated linearly, a question with no clear answer yet.

Two adaptive models have been recently proposed to couple the two laws and answer the above question; given a fixed threshold on the flow velocity's magnitude, these models locally select the more appropriate law as they are being solved. At the end, each mesh cell is flagged as being in the Darcy or Forchheimer subdomain.

In the first model [1], the interface separating the two subdomains is tracked throughout a fixed-point algorithm. More precisely, the velocity is iteratively re-evaluated and, comparing the velocity's magnitude to the fixed threshold, the cells are reflagged as being Darcy or Forchheimer cells. Also, a remeshing is performed: if the opposite edges of a cell have velocities with higher and lower magnitudes than the threshold, then the interface is moved at the center of the cell and a new mesh is generated such that the interface coincides with the edge of two newly created neighboring cells.

In the second model [2], the interface is not localized sharply. Instead, a regularized law is introduced resulting from a smooth average of Darcy's and Forchheimer's laws; this law gradually passes from Darcy's to Forchheimer's, and vice-versa, in so-called transition zones which surround the interface. A classical fixed-point algorithm is then directly run on the regularized law.

In this presentation, we will define these two models in detail, prove their well-posedness using tools from monotone operator theory and variational calculus, and illustrate their behavior via some numerical results obtained on simple, preliminary one- and two-dimensional test cases.

Participation

In-Person

References

[1] A. Fumagalli and F. S. Patacchini. Model adaptation for non-linear elliptic equations in mixed form: existence of solutions and numerical strategies. ESAIM: M2AN, 56(2):565-592, 2022.
[2] A. Fumagalli and F. S. Patacchini. Well-posedness and variational numerical scheme for an adaptive model in highly heterogeneous porous media. ArXiv preprint arXiv:2206.07970, 2022.

MDPI Energies Student Poster Award

No, do not submit my presenation for the student posters award.

Country

France

Acceptance of the Terms & Conditions

Click here to agree

Energy Transition Focused Abstracts

Primary authors: Dr PATACCHINI, Francesco (IFP Energies nouvelles); Dr FUMAGALLI, Alessio (Politecnico di Milano)

Presenter: Dr PATACCHINI, Francesco (IFP Energies nouvelles)

Session Classification: MS08

Track Classification: (MS08) Mixing, dispersion and reaction processes across scales in heterogeneous and fractured media