Contribution ID: **913** Type: **Oral 20 Minutes**

Upscaling the Navier-Stokes Equation for Turbulent Flows in Porous Media Using a Volume Averaging Method

Monday, 14 May 2018 14:07 (15 minutes)

Turbulence in porous media is a phenomena that is more prevalent than commonly thought. Such flows happen in packed bed reactors (e.g., oxidation of petrochemicals), in pebble-bed nuclear reactors (where Reynolds numbers can be on the order of 100,000), and at the fluid-solid interface of rivers to name a few examples. One of the characteristics of turbulent flows is the notable deviation from Darcy's law; the resulting flows are nonlinear, and are described by more-or-less empirical formulations referred to here as the Darcy-Forchheimer-Ergun equation.

In this work, we take a unique approach to the problem by combining conventional volume averaging theory with direct numerical simulation (DNS). Direct numerical simulation seeks to eliminate the *closure models* conventionally used in turbulence theory with simulations of all relevant time and length scales all the way down to the scale of viscous dissipation. DNS simulations are computationally intensive, requiring potentially millions of degrees of freedom to simulate even simple systems containing a small number of grains. The problem of resolution becomes significantly more difficult as the Reynolds number increases.

For the work we report, we provide (1) a revised examination of the upscaling problem as originally examined by Whitaker (1996), (2) development of a novel closure scheme for relating the microscale velocity deviations to the effective macroscale momentum equation, and (3) the results of a sequence of high-Reynolds-number flows, with Reynolds numbers up to 1000. Our DNS results validate our proposed closure scheme; comparison of the *upscaled* and *DNS* momentum balances show that the predicted macroscale flow parameters are able to reproduce the integrated results of the DNS simulations with high fidelity.

References

Whitaker, S. (1996). The Forchheimer equation: a theoretical development. Transport in Porous media, 25(1), 27-61.

Acceptance of Terms and Conditions

Click here to agree

Primary author: WOOD, Brian (Oregon State University)

Co-authors: HE, Xiaoliang (Oregon State University); APTE, Sourabh (Oregon State University)

Presenter: WOOD, Brian (Oregon State University)

Session Classification: Parallel 2-G

Track Classification: MS 1.08: Non-linear flows in porous media: impact of inertia and non-linear rheologies on pore scale processes and applications