Fluid flow process simulation and material property simulations with FlowDict

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FlowDict computes incompressible, stationary and Newtonian flows

Incompressible means not too large pressure differences. True for most liquid applications, not all gas applications.

Stationary means the flow field does not vary with time – for example, no turbulence is modeled.

Newtonian means the fluid behaves like water and not like honey

- Navier-Stokes-Brinkman describe regimes

- EJ, LB, EFV and Fluent are different solvers – they perform differently for the different settings!
Velocity; Flow from bottom to top

Stokes solid obstacle: slower

Navier-Stokes solid obstacle: slowest

Stokes – Brinkman permeable obstacle $\kappa=1\text{e}-12$: fastest

Navier-Stokes-Brinkman permeable obstacle $\kappa=1\text{e}-12$: slower
Process Simulation or Material property simulation?

Two experiments are typical:

- Measure mass flow rate for applied pressure drop
- Measure pressure drop for given mass flow rate

But only for EFV and Fluent both can be specified,

EJ and LB work only for prescribed pressure drop.
Process Simulation or Material property simulation?

All flow solvers always compute the complete velocity field and pressure distribution in the whole computational domain.

I.e., the process / the experiment is always computed.

Sometimes the material property *permeability* is sought.
Computing the permeability

\( \bar{u} \): Macroscopic flow velocity
\( \kappa \): Permeability tensor
\( \Delta p \): Pressure drop

Flow solver finds microscopic flow field. Averaging yields \( \bar{u} \)

Darcy-Law: \( \bar{u} = \frac{\mu}{L} \kappa \cdot \Delta p \)

Clear: permeability is independent of viscosity and velocity in linear regime, i.e. for Stokes flow
Computing the permeability tensor

Permeability tensor: \( \mathbf{K} = \begin{pmatrix} k_{11} & k_{12} & k_{13} \\ k_{21} & k_{22} & k_{23} \\ k_{32} & k_{32} & k_{33} \end{pmatrix} \)

Computation of anisotropic material properties
The PleatGeo Tool
The effect of plain vs twill 2/2

Plain weave, 6 bar

Twill 2/2, 4 bar
(35% lower pressure drop)

Work lead to patent by ARGO HYTOS