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Visualization of flows in 3D-printed fractured porous media: an experimental approach

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In-depth understanding of fluid and solute transport through complex porous media is of significant importance in various engineering and scientific applications. Large-scale behaviour of fluid and solute transport are determined by pore-scale features. Therefore, it is crucial to determine pore-scale transport properties and then upscale these properties to large scales. Numerically lattice-Boltzmann methods (LBM) have shown the potential to simulate flow in porous media with high Knudsen numbers. On the other hand, a limited number of experimental studies have been proposed, and even less actually conducted, to characterize pore-scale flow in porous media with sufficient spatial resolution to test or verify numerical results.

Recent advances in 3D-printing technology offer the capability to precisely manufacture transparent fractured porous media, enabling optical flow visualization employing, for example, Particle Shadow Velocimetry (PSV). In this study, the flow is optically visualized in a transparent fractured porous medium with two flow-through and two dead-end fractures, symmetrically embedded in two matrices with different pore sizes. This medium is designed to represent dual-permeability, dual-porosity porous systems. A LED light source was used to back-illuminate the flow chamber and a monochrome camera was used to record image sequences of the seeded flow through the fractured porous medium. Flow velocities were determined by local pattern cross-correlation. Measured velocities were compared with LBM simulations, performed for the same porous medium geometry. Our results demonstrate the potential of using quantitative flow visualization techniques to characterize fluid flow in complex porous systems.

References

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