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Investigating compressible gas flow through porous media considering the choked condition and shockwave formation for Pulse-Pressure Decay test: A Computational Fluid Dynamics (CFD) approach

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It is well known that when compressible gas expands through a porous system, the flow may be choked at geometrically constricted paths, to limit mass flow rate if inlet and outlet pressure ratio exceeds a critical gas-specific limit, while induces shockwaves along with sharp variations in fluid thermophysical properties. Modelling such flow behaviours and their impacts in time on a porous system is challenging but necessary to design short and long-term operations for geo-energy engineering such as hydrogen storage and carbon capture and storage.

In this work, we model transient flow behaviours of compressible gas in a system which comprises three sequentially connected components: an upstream gas reservoir, a cylindrical pore channel with a throat-forming uniformly wavy radius profile, and a downstream reservoir. Higher pressured gas expands from the upstream reservoir through the channel into the downstream reservoir. The latter two are initialised with the same and lower pressure. This mimics the well-known Pressure Pulse Decay (PPD) setup, for measuring the permeability of tight porous samples containing fractures. We investigate flow choking and shockwaves occurrences across the channel along the time till the upstream and downstream pressure difference is small, for several configurations of initial upstream and downstream pressures and channel radius profiles.

We examined the changes of Mach number and pressures at time and found that choking and shockwaves occur prominently at an early time for cases where the initial pressure difference is large. The Mach number and pressure magnitudes decrease with the decrease of pressure difference. For some cases, the Mach number, at the furthest downstream throat, rather unexpectedly, remains above one even when the pressure difference is always diminishing. In addition, the impact of the choking on the pressure decay of the upstream reservoir and pressure build-up at the downstream is being analysed against counterpart cases where a wavy channel is replaced with a straight channel with an equivalent radius. The results of this work will be reported.

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References

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

Online

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