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CFD simulation of particle capture in open-cell foams: filtration efficiency and comparison with granular beds

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The problem of filtration for flows carrying particulate matter is of interest in many different fields: both for drinking water purification, in biological sterilization processes, or in the chemical and process industry for the removal of solid particulate feed of catalytic packed-bed reactors in refining processes.
Traditional filters show inefficiencies in removing particles with dimensions in the range 1 < dp < 20 μm, or induce too high a pressure drop, due to solid build-up in the filter leading to exponentially increasing pressure drops. The deposition phenomena of such systems are analogous to those described by Yao et al. (1971) for water filtration in granular beds. When the solid density is much higher than the liquid one, the captation is mainly the result of inertial deposition and steric interception with the solid collector.
One potential solution is the use of innovative open-cell ceramic foam structures as filtering media. Their open cellular structure makes them suitable for deep-bed filtration and moreover their high porosity and specific surface results in lower pressure drops compared to other packing media, such as granular beds. However, the influence of their geometrical structure and topology on the characteristic length and filtration efficiency remains an open problem.
The aim of this work is to investigate fluid flow and particles capture inside ceramics foams, to extract the key parameters and characteristic lengths affecting the filtration efficiency and compare them with more classical granular beds. The investigation is carried out performing numerical CFD simulations of the fluid flow inside foams geometries obtained either from x-ray tomography reconstruction or from digital generated model using an improved workflow based on Agostini et al. (2022), allowing the exploration of a large set of parameters, and able to reproduce both the geometrical structure and the macroscopic behaviour of experimentally investigated solid foam structures.The carried solid particles are represented by Lagrangian Discrete Particle Model (DPM) simulations, under the hypothesis of laminar regime and diluted systems and no influence of the particle on the fluid flow.

Participation

In-Person

References

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