A numerical investigation of droplet impingement behavior on micro-CT reconstructed porous media using adaptive interface compression and mesh refinement.

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Droplet impact on porous media has a broad range of applications such as material processing, drug delivery, ink injection etc. The simulation studies of such processes are rather limited. To represent spreading and absorption processes of droplet on porous materials, robust numerical schemes capable of accurately representing wettability as well as, capillary effects need to be established. The current work, presents one of the first studies of droplet impact on a real porous media geometry model extracted from a micro-CT scan. The process involves processing of CT image and subsequent threshold based on the structures segmentation. To extract the computational mesh from micro-CT stack of 2D slices, a specific framework has been introduced. Using RETOMO, a new software package from BETA CAE Systems, segmentation of the 2D X-ray stack images is used to define the rock/air interface contours for the entire volume. The same software was used to then export the interface iso-surface as a STL type mesh. The generated surface mesh was of high quality; however, further mesh operations were conducted in ANSA pre-processor in order to ensure that the pore and throat representations of the rock were kept intact. The solution algorithm is developed within the open source CFD toolbox OpenFOAM. A modified Volume-of-fluid (VOF) method is used to capture the location of the interface, combined with additional sharpening and smoothing algorithms to minimise spurious velocities developed at the capillary-dominated part of the phenomenon (droplet recession and penetration). Moreover, the solver is modified to have adaptive grid refinement and adaptive interface compression for a sharp and accurate interface featuring reduced computational cost. The numerical simulation uses Kistler boundary condition for accurate wetting conditions description at the porous surfaces. A systematic variation of the main factors that affect this process are considered, i.e. wettability, porous size, impact velocity. To investigate the influence of porous structures on droplet spreading, the average porosity of the media is varied between 18.5\% and 23.3\%. The results indicate two different regimes of penetration: inertia and capillary driven regimes. The inertia driven penetration occurs within the time scale of the droplet spreading onto the surface of the porous media, while droplet recoil pauses the penetration process at low Weber numbers.