In the oil and gas industry, gas, oil, water, and sand particles all normally exist in a reservoir. Oil and gas companies need accurate information on the location of oil within porous media (such as rock and sand) to help them determine where to drill and to evaluate existing oil reservoirs. It is also important to know where extensive sand deposits exist within porous media. Therefore, there are lots of data processing and physics computing in analyzing the situation of the reservoir. With new methods available to address complex physical phenomena, and advances in powerful computing platforms, the ability to model fundamental flow physics at high resolution becomes both essential and possible. It offers the promise of developing reduced order models for large scale processes that retain the fundamental physics in a rational manner. Fig. 1 shows the geometry of a 3D digital porous media sample.

For simulating complex multiphase flows in oil reservoirs, a mathematical model was developed to describe the multiphase flow in the oil reservoir based on OpenFOAM [2]. In the multiphase flow model used in this study, every single fluid phase was presented by Navier-Stokes fluid flow governing equations and solid particles were presented directly by the Lagrangian motion equation using discrete particle model (DPM). Therefore the mathematical model for the multiphase flow is a coupled Eulerian-Lagrangian model. Furthermore, in the multiphase flow model, the VOF (used of fluid) method was introduced to capture the interface between fluid phases. Due to the Eulerian-Lagrangian coupling, the coupling between discrete particle model (DPM) and volume of fluid (VOF) method was also developed for this multiphase flow model. Fig. 2 shows the validating simulation of solid particles passing through the oil layer and water layer with gas bubbles.

The solid particles with gas were injected into the inlet hole at the bottom. First, the gas-particles pass through the water layer in the inner riser, then enter the oil layer, and are finally thrown out of the free surface at the top of oil layer. During the processing of solid particles thrown out off the free surfaces, some of the water and oil droplets may also be carried out into the air. Due to gravity, these heavy particles with liquid droplets fall down into the oil layer and subsequently into the water layer again outside of the inner riser. This processing is a gas-liquid oil-water-based 4-phase flow, which was simulated by the multiphase flow model with coupled DPM and VOF developed for this study.

In the oil reservoir the flow normally is a multiphase flow including gas, oil, water, and solid particles. Therefore the simulation should be physically realistic for gas-liquid-acre-based 4-phase flow, i.e. the 4 phases flowing together pass through the porous media with a micro-pore structure. Because the flow process is very complicated and the structure is also complex, the simulation is very time-consuming at large scale. It usually requires a powerful supercomputer to perform these numerical simulations. In this study, the numerical simulations were performed on Intel's Endeavor cluster [3] with Intel Xeon Phi Knight's Landing cards (KNL) at the same time with the optional optimizations for HPC.

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Related Websites:
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