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Simulating Water-in-oil Emulsions in OpenFOAM®

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ABSTRACT

In this study, a modified OpenFOAM® solver (*MIDPFoam*®) that couples the multiphase computational fluid mechanics and Discrete Element Method (CFD-DEM) is presented. This solver can be used to model various industry-relevant problems, such as predicting the efficiency of a sand separator, where the flow is a mixture of water, oil, water-oil emulsions and air, and the particles are injected into the domain. This is a common phenomenon in Alberta, where most oil wells produce sands, which can lead to significant risk to surface infrastructure and shortening their life span. Therefore, the sand separator is an important tool used inline to clean the produced oil. The *MIDPFoam* remedies two disadvantages of current existing two-way coupled CFD-DEM solvers when simulating the sand separator problems. First, the Volume of Fluid (VOF) method obtained from *multiphaseInterFoam* is implemented into the solver so that it can handle more than two different fluids with particles, whereas others have a limitation of maximum of two fluids in the computational domain. Second, the produced fluids from the wells are usually presented as mixtures of water and crude oil, known as emulsions. However, the multiple fluid phase mixture model in most CFD software cannot correctly represent the rheological behaviour of emulsions. This is because the emulsion viscosity tends to follow an exponential function trend on both sides of the inversion point rather than the default linear function behaviour. Hence, to accurately calculate the effective viscosity of the emulsion, a Heavyside step is implemented in the multiphase mixture model. The *MIDPFoam* is modified based on *denseParticleFoam*, which includes modifying of the governing equations, coupling the *denseParticleFoam* with VOF method and implementing the Heavyside step functions. With performing these steps, the *MIDPFoam* is developed to be capable of simulating the water-in-oil emulsions during sand separation and transportation. Moreover, the new *MIDPFoam* will be validated by comparing with the sand separation efficiency obtained from the experiments.

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