8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

COUPLING SOLIDS IN FLUIDS APPLIED TO PETROLEUM RESERVOIR SIMULATION

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Key Words: *Multiphysics Problems, Petroleum Reservoir, Discrete Element/LBM.*

ABSTRACT

In this paper we present an overview of coupling discrete solids immersed in a fluid for analysis of geomechanics problems in petroleum reservoirs. Several different frameworks have been used to model the coupled physics of fluid-solid systems, ranging from complete continuum approximations [1] to purely discontinuous approximations [2]. Most frameworks employ some empirical constitutive relations governing fluid flow (e.g., Darcy's law) and fluid coupling (e.g., effective stress) with the most common example being the assumption of Darcy flow. Several micro-mechanical models were recently developed using discrete elements coupled to a continuum fluid flow scheme based on Darcy's law that yielded good results [3-6]. Several authors justify this type of approach by suggesting that individual discrete elements are not single grains but groups of grains instead. As a consequence, these models must use empirical relations, such as the Kozeny-Carmen equation, to relate porosity to permeability. Previously published results for the coupled model focused on few or multiple particles in a fluid while here we show results with good agreement to packed assemblies of particles (i.e. porous media).

One of the key problems in modelling grains immersed in a fluid is handling the boundary condition at the grain surface. Here we detail the so called "immersed boundary condition" for lattice-Boltzmann presented by Noble and Torczynski [7] and later modified by Holdych [8]. This method uses a modification of the lattice-Boltzmann collision operator for partially solid computational fluid cells. The Noble and Torczynski condition has been applied in two dimensions by Cook and others [9] and in three dimensions by Holdych [8] and Strack and Cook [10].

Finally, the model is applied to sand production, a common problem in the geomechanics of petroleum reservoirs.

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