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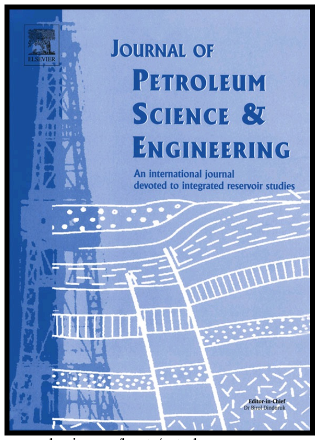

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Improving Multiscale Mixed Finite Element Method for Flow Simulation in Highly Heterogeneous Reservoir using Adaptivity

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Abstract: We present an adaptive **M**ultiscale **M**ixed **F**inite **E**lement **M**ethod (**MsMFEM**) for modeling multiphase flow in highly heterogeneous reservoir. In this framework, fractional flow model is used to approximate pressure and velocity solution on coarse scale, while resolution in fine scale is honored by the basis functions, which are calculated by local problems on fine scale. The adaptive computation in the flow problem is permitted by two different basis functions. In the numerical examples, our adaptive MsMFEM is applied to solve two dimensional and three dimensional reservoir simulation problems with highly heterogeneous porosity and permeability fields. The preliminary numerical simulation results presented show a significant speedup in comparison with the reference numerical method, which encourage and is beneficial for further investigation of the proposed method for reservoir numerical simulation.

Keywords: reservoir simulation; adaptivity; multiscale mixed finite element method; heterogeneity; multiple scale;

1. Introduction

A lot of important problems in engineering and science fields are fundamentally multiscale problems, such as heterogeneous porous media and composite materials. Direct numerical simulation for such problems is not realistic, because it takes tremendous computer memory and computational time, which is even beyond the capacity of today's computer resources. Considering the difficulties in numerically resolving all scales, it is often sufficient to simulate multiscale problems by conserving a certain accuracy. Therefore, upscaling or multiscale methods are typically adopted for such heterogeneous systems [1-4].

Upscaling methods is mainly relied on the idea of forming coarse scale solutions with a prescribed analytical approach. In geological modeling area, numerical upscaling methods based on detailed geological models has received much attention recently. Those upscaling methods evaluates permeability field in porous media, and basically two main procedures are involved. Fluid flow through porous media on fine scale is firstly modeled. Secondly, fine scale information is incorporated into coarse scale flow properties, e.g. permeability. Here how to realize the second procedure is vital, and those methods have gained success [6-9]. However, when complex fluid flow processes in highly heterogeneous systems are studied by coarse models with simplified settings, it is very difficult or even impossible to obtain a priori estimates of the errors.

On the other hand, in multiscale methods fine scale information is dynamically absorbed throughout the simulation loop. Besides, those coarse scale equations are generally formulated and solved numerically but not analytically. In literatures a lot of multiscale methods have been proposed, e.g., Heterogeneous Multiscale Method (HMM) [10], Multiscale Finite Element Method (MsFEM) [11] and variational multiscale method [12]. Multiscale methods have also been promis-