X-DMS 2015
eXtended Discretization MethodS
September 9-11, 2015, Ferrara, Italy

Non-matching schemes for upscaling in fractured porous media

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Key words: Fractured porous media, numerical upscaling, embedded discrete fracture matrix, extended finite element methods.

ABSTRACT

The accurate modeling of flow in reservoir characterised by the presence of complex, extremely interconnected, networks of fractures is important for many subsurface flow problems like CO_2 storage, oil migration and recovery or groundwater contamination. This poses various challenges including the need to develop reliable and efficient mathematical models to describe the networks of fractures. Typical numerical methods, which are effective to handle few fractures, are often characterised by an high computational cost. Numerical upscaling techniques suitable for dual porosity/dual-permeability-like models [3, 6, 9] are then required to reduce the computational effort. The key point in these methods is the solution of local problems to compute the upscaled parameters.

To solve the local problems, the discrete fracture matrix (DFM) method represents one of the most accurate methodologies for describing such kind of fluid flows. DFM method can be viewed as a reduced model, like in [8, 1], to describe the fracture flow and exchange among fractures and matrix systems, where the fractures are represented as objects of co-dimension one. The method DFM entails the direct numerical simulation of the flow through the porous medium normally using an explicit discretization of fractures and matrix in a conformal framework. To remove geometric constraints that could affect the gridding, we consider two possible approaches: the embedded discrete fracture matrix (EDFM) [7] method, overcoming the need to use conformal grid for fractures and matrix, and a suitable finite element space enrichment in the extended finite element method (XFEM) framework [2, 4, 5] to allow pressure and velocity jumps inside grid elements for the fractures and rock matrix.

Our work is focused on the implementation of a suitable flow-based upscaling methodology and aims at deriving effective properties for dual-media simulators based on a two-point concept to link different coarse elements. In this framework, to increase the accuracy of the flux through matrix elements we consider the multiple sub-region algorithm [6]. The upscaled parameters include inter block transmissibility for fracture elements, and sub-region transmissibility for the matrix cells. Effectiveness and efficiency of the method comparing the XFEM and EDFM approach is proved by means of synthetic but representative test cases.

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