A Comparison of Discrete Fracture Models for Single Phase Flow in Porous Media Using COMSOL Multiphysics® Software

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Abstract

In this work, a comparison of discrete fracture models for single-phase flow in porous media using COMSOL Multiphysics® software is presented with the aim to understand the contribution of each individual fracture to fluid flow, and the exchange between fracture and surrounding medium at a scale such that the fractures could be modeled explicitly.

The derived flow models in fractured porous media are single phase, slightly compressible, based on the fluid pressure and considering the Darcy's law for fluid velocity in the porous media. In addition, it is assumed that the fractures are filled with a porous material and that flow in the fractures also follows the Darcy's law.

Discrete fracture model approach basically consists in representing fractures as (n–1)-dimensional objects in an n-dimensional domain, i.e., in 2D fractures could be represented by line segments and in 3D by polygons.

Two discrete fracture models are here presented: in the first one fractures are represented as boundaries between subdomains, this is the domain decomposition approach, while in the second one fractures are represented by isolated internal boundaries. Both models take into account interactions between the fractures and the surrounding porous medium. The numerical implementation is carried out applying the PDE coefficient mode and weak PDE form to describe flow along the interior boundaries. A third model, a single-porosity one, considering fractures as a porous medium subdomain with different petrophysical (porosity and permeability) properties is implemented as a reference case for comparison proposes.

Finally, the discrete-fracture and single-porosity models are numerically validated in a injection-production case study in two dimensions.

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4