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Permeability Models for Enhanced Geothermal Systems with Diffuse Fractures using GFEM and Micromechanics

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ABSTRACT

Fluid flow in geomaterials with an existing fracture system as is usually encountered in Enhanced Geothermal Systems is strongly influenced by the distribution and the orientation of the cracks. To model the effective transport properties requires up-scaling of transport processes within these fractures and their interaction with the surrounding porous material across multiple scales. To this end two modeling strategies based on the concept of the REV are proposed and compared in the paper.

The first strategy is based on continuum micromechanics. Here, the REV represents distributed fractures idealized as ellipsoidal inclusions in a porous matrix. The corresponding 'pressure gradient' localization tensors are computed using the ESHELBY matrix inclusion technique. The effective permeability is anisotropic and depends on the permeability of the porous material in the vicinity of the fracture, the topology of the fractures, the fracture density and their distribution. To investigate the percolation probability of the fracture network, we use the CCM model [1]. The model predicts a fracture percolation threshold for a particular fracture density as a function of the topology of the fractures. This provides initial estimates for the connectivity characteristics of the fracture system.

The second strategy is based on a discrete hybrid XFEM-GFEM [2] model for numerically simulating hydraulic fracturing in deep geothermal reservoirs. The numerical REV consists of embedding discrete fractures using the standard HEAVISIDE function for the approximation of the displacement field at the fracture. The fracture system is algorithmically generated from user data. The fluid pressure field in the vicinity of fracture is approximated using the local continuity equation for the fluid flow in the normal and tangential directions together with the analytical solution from the consolidation problem [2]. As predicted by the continuum model, the total fluid flow is also modified due to the presence of discrete fractures.

The model predictions of both the discrete and the continuum strategy are compared and contrasted for various scenarios such as the influence of the orientation of the fractures, the influence of the fracture density and the influence of the fracture topology.

REFERENCES

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