Large scale DFN and DFM simulations using non-conforming meshes

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PDE constrained optimization approach. In [1, 2, 3] a new optimization approach for solving the flow problem in large scale DFNs is presented. The approach is based on a reformulation of the problem as the minimization of a functional measuring the mismatch of the hydraulic head and the unbalance of the fluxes at the fracture intersections, constrained by the flow equations on the fractures. This optimization approach can be extended to the coupling of DFN with the surrounding rock matrix. The minimization is performed via a Conjugate Gradient method and is suitably developed to be efficiently parallelized with several parallel approaches or using different parallel architectures (shared memory and distributed memory systems or graphical accelerators). Large scale systems (see Figures 1 and 2) have been tackled by this approach both considering the surrounding rock matrix impervious [3] or including in the model the flux exchange with the surrounding matrix [4].

Virtual Element based methods. In [5, 6] the possibility to relax the difficulties of conforming mesh generation is based on the use of quite general polygonal elements. Two possible options lead to the generation of a totally conforming mesh or to a partially conforming mesh with mortar matching conditions. The construction of the polygonal mesh is roughly based on a cutting process of independently generated triangular meshes on the fractures. Although the mesh produced by this process usually displays elements with a large aspect ratio or elements with small angles (Figures 3, 4), the quality of the solution obtained is in general good and resorting to the conformity of the meshes to the traces, virtual elements of order larger than one can be applied. Within the mortar approach, the solution obtained directly provides both the hydraulic head and the fluxes at the traces, without the need of a post-process computation of the flux starting from the computed hydraulic head.

Transport problems. Both methods have been applied to unsteady transport problems for a passive scalar. Due to the small diffusion or dispersivity parameter the discretization should be able to deal with highly convective-dominated regimes. For this target a SUPG-like stabilization has been developed in the context of VEM discretizations [7] and implemented. In [8] the unsteady transport problem is considered in conjunction with an uncertainty quantification analysis in a framework in which the transmissivity of the fractures is given by a random field.

References

Figure 2: Example of fracture network and surrounding rock matrix

Figure 3: Example of VEM polygonal mesh

Figure 4: Detail of VEM polygonal mesh


