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Coupled thermal-hydraulic-mechanical simulation for enhanced geothermal system based on embedded discrete fracture model

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As the most effective method for mining deep geothermal resources, the enhanced geothermal system (EGS) has become a hot topic in the recent geothermal researches. To extract heat storage in the Hot Dry Rock, hydraulic fracturing technology is used to form artificial flow aperture. Subsequently, the geothermal energy is extracted through heat carrying fluid cycle. The mining process includes porous flow, heat exchange and deformation of rock, which is a typical thermal-hydraulic-mechanical (THM) three field coupling problem. Recently, some scholars have carried out a preliminary numerical simulation study on the multi-field coupling in EGS [1-5]. However, there are still two main shortcomings. First, the simulation of fractured rock mass is mostly based on continuum hypothesis, which is only suitable for rock with relatively high porosity. This method shows large error for EGS system dominated by several fractures. Second, the research on heat flow coupling is not enough, which is the most basic and important aspect in EGS. Especially, the study of heat transfer process and heat recovery efficiency under thermal-fluid coupling is not yet thorough. Therefore, based on the embedded discrete fracture model (EDFM), the THM coupling model of the actual fractured rock mass is established. Two energy equations are used to describe the heat transfer process in the matrix and fracture respectively. Finite volume method (FVM) is applied to discrete energy equation, two point flux approximation (TPFA) method for porous flow equation and finite element method (FEM) for solid skeleton deformation equation.
All variables are solved simultaneously through the Newton-Raphson iterative method, the calculation of the Jacobian matrix uses automatic differentiation algorithm. The influence of reservoir heterogeneity, anisotropy, injection rate, injection pressure and well spacing on the exploitation temperature of EGS system is emphatically analyzed.

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