

Mechanism of complex fracture creation in hydraulic fracturing

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Hydraulic fracturing has been used to improve the permeability of rock for development of unconventional resources. A complex fracture network created by hydraulic fracturing significantly improves the permeability of rock and increases the production of natural fluid resources. The heterogeneity of rock strength has in fact a great influence on the fracture shape created in uniaxial tension test, fracture toughness test, or hydraulic fracturing. Such heterogeneity is, however, rarely taken into account in the evaluation for complex fracture network creation in development of unconventional resources. The mechanism of fracture creation is not fully revealed yet, either. In the present study, we reveal the mechanism of complex fracture creation in the presence of heterogeneity in rock strength in the fracking. We perform a series of numerical simulation using models not only with strength heterogeneities but also as a function of brittleness that is kept constant in each model. As a results, it is turned out that the mechanism of complex fracture creation due to the heterogeneity in rock strength is completely different from that in brittleness. In hydraulic fracturing with heterogeneous models, a number of micro cracks are generated around the tip of main fracture that does not propagate straight due to these precedent micro cracks. In addition, pores with specific shape and the spatial inhomogeneity in the rock strength at the tip cause the divergence of main fracture and, then, a complex network of hydraulic fractures could be formed. In hydraulic fracturing of rocks with high brittleness, shear failures occur around the main fracture filled with fracturing fluid, and a lot of branches are created. Since the deformation of induced fracture is restricted in media of high Young modulus, fluid pressure acts on fracture surface becomes high. This induces strong shear stress field around main hydraulic fracture. In conclusion, the mechanisms of complex hydraulic fracture due to strength heterogeneity and that due to brittleness are completely different, and the heterogeneity in rock strength should be taken into consideration for the accurate evaluation of complex fracture creation.

Keywords: hydraulic fracturing , discrete element method, strength heterogeneity, brittleness