Poroelastic Effects Influence Range for Radial Hydraulic Fracturing Model

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Hydraulic fracturing is a part of modern technologies for hydrocarbon production intensification. The hydraulic fracture propagation is stimulated by the pumping of a viscous fluid which creates pressure on fracture's walls high enough to overcome the rock confining stresses and cause the rock failure. The process of the hydraulic fracture growth is governed by several factors: the flow of the viscous fluid in a narrow fracture's gap, the elastic reaction of the fracture's walls, and the filtration of the fluid from the fracture to the reservoir, the rock failure and advance of the fracture front.

In recent years, the fracture mechanics community have been attracted to finite element modelling (FEM) of the hydraulic fracturing process in poroelastic formations. However, the open question is whether the poroelastic effects are essential in case of the hydraulic fracturing process. In present work we investigate this subject using numerical analysis. We consider the model of radial hydraulic fracture in a poroelastic medium constructed similarly to one in plane strain case [1]. The model makes it possible to calculate the pore pressure and the rock deformation coupled with the fracture openning. The reservoir mechanics is governed by Biot poroelasticity equations [2]. The fracturing fluid flow is determined by the lubrication equation. In order to account for the fracture toughness the cohesive zone model is adopted. The advantages of this approach are that it assumes a natural fluid exchange between fracture and surrounding porous medium and the influence of the pore pressure on the rock stress state.

The numerical solution of the problem is constructed by the finite element method with the use of a modification of the algorithm proposed in [1]. The correctness of the numerical algorithm is verified via comparison with analytical solutions. Carrying out a series of numerical simulations we find the range of influence of the poroelasticity and 3D diffusion (Carter's law violation) effects for the radial hydraulic fracturing model. The results are presented in terms of dimensionless complexes and typical values of the hydraulic fracturing parameters. The demonstrated results can help to choose a proper hydraulic fracturing model in engineering practical cases.

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References

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