Hydraulic fracturing modeling using finite elements with high aspect ratio

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ABSTRACT

Hydraulic fracturing is a technique widely used to enhance the reservoir permeability in petroleum engineering. A viscous fluid is injected into a well at high pressure in order to break the surrounding rock. This process triggers the initiation and propagation of fractures, which form channels with high permeability and facilitate the flow of hydrocarbons. This kind of problem has several challenges, because the hydraulic fracturing involves the coupling of many physical processes, such as the fluid pressure that alters the effective stresses deforming the porous medium; fluid flow inside the crack; fracture propagation through the rock; and fluid leak-off. Analytical and numerical techniques have been proposed to simulate hydraulic fractures, but they have limitations that simplifies the models. This work presents a technique capable of capturing the main phenomena related to the initiation and propagation of hydraulically induced fractures that is developed in the framework of the FE method. The deformable porous medium is modeled by considering a hydro-mechanical formulation and the problem is solved in a fully-coupled manner, considering the fluid flow via Darcy's law, deformation by means of effective stresses and changes in rock transmissibility related to fracture-aperture effects according to the cubic law. This work demonstrates that FE with a high aspect ratio (HAR) [1] are also able to properly describe the formation and propagation of hydraulic fracture in the context of continuum mechanics by adopting a continuum tensile damage model. Following the KGD model assumption [2], an unique fluid-driven fracture is studied in this work. The new model results are compared against the analytical solution other published numerical results. After analyzing the model outputs in terms of fracture aperture, length and pressure, it can be stated that HAR elements are very promising to model problems involving the formation and subsequent propagation of fractures in rocks triggered by hydraulic fracturing processes.

REFERENCES

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