Well stimulation in tight formations: a dynamic approach

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Abstract

Hydraulic fracturing has been widely employed for well stimulation in the last five decades. Different techniques, equipment, fracturing fluids and proppants have been utilized in practice to optimize the fracturing process. However, it has some disadvantages including a lack of control over the direction of fracture propagation, the high treatment cost along with some challenging environmental issues. Dynamic stimulation techniques generating multiple fractures in a wellbore to enhance gas recovery are nowadays attracting more attention in oil industry. Producing multiple fractures seems to be more promising in naturally fractured reservoirs, since it is an effective way for connecting a pre-existing fracture network to a wellbore. Applying high rate loading by explosives and propellants are the two common methods for dynamic stimulation of a well.

In this study, an interfacial damage model implemented in a Spacetime Discontinuous Galerkin (SDG) finite element method is utilized to simulate fracturing in rocks. A powerful dynamic mesh adaptivity scheme is implemented to track arbitrary crack paths and align them with element boundaries. Besides, the transitions between different contact modes are well undertaken using a dynamically consistent damage-contact model fitting for rocks under compressive and shear loadings.

Two applications are presented. One focuses on explosive fracturing and the other deals with propellant fracturing. High explosives detonate and produce a shockwave that causes extreme compressive stresses to enlarge the wellbore by crushing and compacting the rock. Propellants can generate a pressure pulse producing a fracturing behavior that loads the rock in tension. The main advantage of this later approach is to create multiple fractures and consequently prepare the well for an effective hydraulic fracturing with much lower cost as a re-fracturing solution.