Performance Evaluation of Hydraulically Fractured Horizontal Wells in a Tight Formation by Coupling Fluid Flow and Fracture Mechanics

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Abstract

Not only does production from a hydraulically fractured horizontal well in a tight formation cause stress field changes, but also results in changing fracture conductivity. It is a challenging task to describe such changes due mainly to the composite effect from flow behaviour and fracture mechanics. In this study, theoretical models have been formulated, validated, and applied to examine effects of non-Darcy flow and fracture mechanics on performance of a horizontal well with multiple fractures in a tight formation. More specifically, the Barree-Conway model is applied to describe the non-Darcy flow behaviour in the hydraulic fractures, while the Biot model is incorporated to take the fracture mechanics into account. Then, a semi-analytical method is applied to solve the coupled mathematical models by discretizing each hydraulic fracture into small segments. For each segment at each time step, the pore pressure distribution is obtained with slab-source functions, while stress field and fracture conductivity are sequentially updated with respect to the pore pressure distribution within a fracture. The pressure response and its corresponding derivative type curves are generated to examine the effect of non-Darcy flow behaviour together with fracture mechanics. The non-Darcy flow behaviour is found to impose a significant impact on the pressure response, inducing an additional pressure drop. In addition, reservoir pressure with consideration of the fracture mechanics decreases faster than that obtained by the traditional methods at early production stage. Also, an increase in effective stress leads to a smaller fracture conductivity, resulting in a faster pressure drop during production. It is found from field applications that coupling fluid flow and fracture mechanics tends to obtain the most reasonable matching results and that there exists an excellent agreement between the measured and simulated pressure, especially at the early production stage.

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