The near-tip region of a hydraulic fracture with pressure-dependent leak-off and leak-in

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Engineering simulators for modelling of hydraulic fractures include a fracture propagation criterion which is based on the near-tip region model. The current work is devoted to the consideration of the near-tip zone of a fluid-driven fracture propagating in a permeable elastic reservoir with account for the pressure-dependent leak-off to, and leak-in from, the ambient porous medium [1, 2]. The model is represented by a semi-infinite fracture moving with a constant velocity. The energy dissipates via two different mechanisms: toughness-dominated rock fracturing and viscosity-dominated fluid friction at the fracture walls. The model also accounts for three fluid balance mechanisms: storage in the fracture, leak-in to and leak-off from the fracture. In the model, the mass exchange rate between the fracture and the reservoir depends on the pressure drop between the pressure of the fluid inside the fracture and the pressure of the pore fluid in the far-field reservoir. As a result, the leak-in and leak-off are one-dimensional pressure-dependent processes dominating near and away from the fracture tip, respectively. We assume that the hydraulic fracturing and pore fluids are identical. In this work, we obtain general numerical solutions for opening and pressure along the fracture and derive analytical asymptotic expansions for near, intermediate and far fields. Based on the found solutions, we construct the solution regime maps within the problem parametric space (e.g., [3]), identifying the parametric domains corresponding to the various limiting regimes of hydraulic fracture propagation. In particular, we able to systematically assess (a) the impact of the near-tip cavity with a circulation of the formation pore fluid [1] on the hydraulic fracture propagation, and (b) the limitations of Carter's law for the leak-off description (pressure-independent).

References

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