SPEED EQUATION, ASYMPTOTIC UMBRELLA AND EXPLICIT LEVEL SET METHOD IN HYDRAULIC FRACTURE MODELING

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Hydraulic fracturing (HF), being a key means to increase oil, gas and heat production, its numerical modeling is of importance for making proper engineering decisions. To improve the efficiency of numerical simulation of HF, we revisit the fundamentals of the mathematical problem. We reveal those features of the problem formulation, which are of prime significance while not accounted for in conventional approaches. The key role of the particle velocity and the speed equation (SE) is emphasized.

It is shown that when neglecting the lag, the asymptotic behavior of the opening w is uniquely defined by the speed v_* of the fracture propagation. On one hand, this fact makes the HF problem ill-posed and causes computational difficulties, when trying to solve it as a boundary value problem under fixed position of the front. On the other hand, when properly employed, the very fact significantly facilitates finding analytical and numerical solutions. In particular, it provides simple analytical solutions for non-Newtonian fluids, which otherwise hardly can be obtained. It also provides the means for employing explicit, as well as implicit, level set methods for efficient numerical tracing of the fracture propagation.

We derive analytical equations for the asymptotic "umbrella", which presents the universal dependence $w(v_*)$. They are applicable for arbitrary power-law fluids in a wide range of propagation regimes from the viscosity dominated to leak-off dominated regime. We conclude that the improvements suggested notably extend options for modeling of HF.