Resfrac: Hydraulic Fracturing and Reservoir Simulator

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Multiphase Forchheimer flow with gravity and non-Newtonian fluid
Handles closure, with or without proppant

\[
\frac{\Delta \phi_p}{\Delta x} = \frac{q_{fc}}{W} \left( \frac{12 \mu_p}{E^2 K_{P,cr}} \right) + \frac{\text{sgn}(\Delta \phi_p) \left( \frac{q_{fc}}{W} \right)^2 \mu_{rof} R_{P,cro} \rho_{P,cro} \phi_p}{E^2 K_{P,cr}}
\]

\[
\frac{\Delta \phi_p}{\Delta x} = -\left( \frac{q_{fc}}{W} \right) \frac{1}{M_{P,b} + M_{P,c}} \text{sgn}(\Delta \phi_p) \left( \frac{q_{fc}}{W} \right) \mu_p - \frac{M_{P,c}}{M_{P,b} + M_{P,c}} \rho_{P,cro} \phi_p
\]

\[
\gamma_f = \frac{E_{op}}{0.1(E_0 + E_{op} + E_{cro}) + E_{op}}
\]

\[
q_p = \gamma_f q_{fc} + (1 - \gamma_f) q_{fc}
\]

\[
\phi_p = \phi_p - \rho_g (\gamma_f \phi_p + (1 - \gamma_f) (\phi_p \rho_{P,b} + (1 - \phi_p) \rho_{P,c})),
\]

\[
\mu_p = \frac{\phi_p}{1 + \frac{\phi_p}{R} (\gamma_f)^{-n} (\frac{\phi_p}{\gamma_f})^{-n}}
\]

\[
\phi_p = \frac{\phi_p}{1 + \frac{\phi_p}{R} (\gamma_f)^{-n} (\frac{\phi_p}{\gamma_f})^{-n}}
\]

Case 1(a,b,c,d)
- Leakoff calculation is fully numerical (not 1D or Carter).
- Permeability of 17.85 md in (a) and (b) and 71.5 nd in (c) and (d), isotropic.
- Leakoff becomes ellipsoidal in 1a and 1b

Case 6(a,c)

Case 7b

Continuing the simulation after shut-in: