HW#9

Assigned: Tuesday, October 27, 2009

Due: Tuesday, November 10, 2009

Compute the solution for the 1-D problem using the implicit pressure form of the flow equation. This requires a matrix solve for P_o^{n+1}. Feel free to use the solvers posted on the web page or some other solver if you prefer. Use the data provided at the end. For now, $\nabla D = 0$.

Flow equation: $$\frac{\partial}{\partial x} k \left(\lambda_T^n \frac{\partial P_o^{n+1}}{\partial x} - (\lambda_w^n \gamma_w^n + \lambda_o^n \gamma_o^n) \frac{\partial D}{\partial x} - \lambda_w^n \frac{\partial P_{cow}^n}{\partial x} \right) + \hat{q}_T^{n+1} = \phi C_T \frac{\partial P_o}{\partial t}$$

(a) Summarize the finite difference equations you use for this assignment. Please note that you will need to include the 2-D version of this in your final project.
(b) Plot Sw vs. x for various times. Compare with the solution of HW #3, Case 3.
(c) Plot the oil recovery factor vs. time.

Data:

$$k_{row} = k^*_{row}\left(\frac{S_o - S_{owr}}{1 - S_{wr} - S_{owr}}\right)^{n_{ow}} \qquad k_{rw} = k^*_{rw}\left(\frac{S_w - S_{owr}}{1 - S_{wr} - S_{owr}}\right)^{n_w}$$

$$P_{cow1} = \alpha \ln\left[\frac{1 - S_w - S_{owr}}{1 - S_{wx} - S_{owr}}\right] \qquad P_{cow2} = -\alpha \ln\left[\frac{S_w - S_{wr}}{S_{wx} - S_{wr}}\right]$$

$$P_{cow} = \begin{cases} P_{cow,max}, & S_w \le S_{wr} \\ P_{cow,min}, & S_w \ge (1 - S_{owr}) \\ \min[P_{cow2}, P_{cow,max}], & S_{wr} \le S_w \le S_{wx} \\ \max[P_{cow1}, P_{cow,min}], & (1 - S_{owr}) \ge S_w \ge S_{wx} \end{cases}$$

Data:

$\Delta t = 0.1 day$, $t_{max} = 10 days$

$NX = 10$, $\Delta x = 10\, ft$, $\Delta y = 10\, ft$, $\Delta z = 10\, ft$

$k^*_{rw} = 0.1 \quad k^*_{row} = 0.7 \quad n_w = 1.5 \quad n_{ow} = 2.5 \quad S_{orw} = 0.30 \quad S_{wr} = 0.25$

$\alpha = 0.8$; $S_{wx} = 0.5 \quad P_{cow,max} = +5\, psi \quad P_{cow,min} = -5\, psi$

$\mu_w = 0.6 cp \quad \mu_o = 2.4 cp \quad \gamma_w = 0.433\, psi / ft \quad \gamma_o = 0.433 * 0.8\, psi / ft$

$\phi = 0.20$, $q_T = 200\, ft^3 / day$, $k = 100 md$

$P_i = 2000\, psia$, $P_w = 1900\, psia$, $S_{wi} = 0.25$

$C_\phi = 3{\cdot}10^{-6}\, psi^{-1}$, $C_w = 4{\cdot}10^{-6}\, psi^{-1}$, $C_o = 10{\cdot}10^{-6}\, psi^{-1}$