1 Modeling HPAI

We inject air at high pressures into a light oil reservoir. The air consists of oxygen and inert component Υ (a mixture of carbon dioxide and nitrogen). The injected air is miscible in all proportions with the oil thanks to the high pressures. The mixed phase consists of three components, viz., oil ($j = 1$), oxygen ($j = 2$) and inert component ($j = 3$) . The oil reacts with oxygen to produce inert component.

$$\nu_1 oil + O_2 \to \nu_3 \Upsilon$$

We disregard any volume change due to reactions and temperature expansion and compositional mixing.

There are four equations, i.e., a three balance equations for each component and heat equation.

$$\varphi \partial_t c_1 + u \partial_x c_1 = \partial_x \left(\varphi D \partial_x c_1 \right) - \nu_1 R_1$$

$$\varphi \partial_t c_2 + u \partial_x c_2 = \partial_x \left(\varphi D \partial_x c_2 \right) - R_1$$

$$\varphi \partial_t c_3 + u \partial_x c_3 = \partial_x \left(\varphi D \partial_x c_3 \right) + \nu_3 R_1$$

$$\partial_t ((C_m + \varphi C_o)\Delta T) + \partial_x (C_o \rho_o u \Delta T) = \lambda \partial_x^2 T + Q R_1, \tag{1}$$

2 Koval model

$$\varphi \partial_t c_1 + \partial_x u f_1 \left(c_1, c_2 \right) = -\nu_1 R_1$$

$$\varphi \partial_t c_2 + \partial_x u f_2 \left(c_1, c_2 \right) = -R_1$$

$$\varphi \partial_t c_3 + \partial_x u f_3 \left(c_1, c_2 \right) = +\nu_3 R_1$$

$$\partial_t ((C_m + \varphi C_o)\Delta T) + \partial_x (C_o \rho_o u \Delta T) = \lambda \partial_x^2 T + Q R_1, \tag{2}$$

where

$$f_i = \frac{c_i / \mu_i}{c_1/\mu_1 + c_2/\mu_2 + c_3/\mu_3}$$

where $\mu_1 = \mu_o$ and $\mu_2 = \mu_3 = \mu_{mix}$. The saturations c_1, c_2, c_3 are volume fractions, and there for ν_1, ν_3 have to be adapted.

$$\left(\frac{1}{\mu_{mix}} \right)^{1/4} = 0.22 \left(\frac{1}{\mu_{gas}} \right)^{1/4} + 0.78 \left(\frac{1}{\mu_{oil}} \right)^{1/4} \tag{3}$$

The oil viscosity is given by $\ln(\mu_o) = 1335.8/T - 4.6329$, where μ_o is in $[mPas]$ and T in $[K]$

3 Two phase simulation

$$\varphi \partial_t S_o c_{o1} + \partial_x u f_o c_{o1} = \partial_x \left(\varphi D S_o \partial_x c_{o1} \right) - \nu_1 R_1 + E \left(\frac{c_{o1}}{c_{g1}} - Q_{eq1} \right)$$

$$\varphi \partial_t S_g c_{g1} + \partial_x u f_g c_{g1} = \partial_x \left(\varphi D S_g \partial_x c_{g1} \right) - E \left(\frac{c_{o1}}{c_{g1}} - Q_{eq1} \right)$$

and the same for the other terms