Flow Modelling of Injection Orientation of Supercritical CO_2 in Porous Media for Enhanced Gas Recovery

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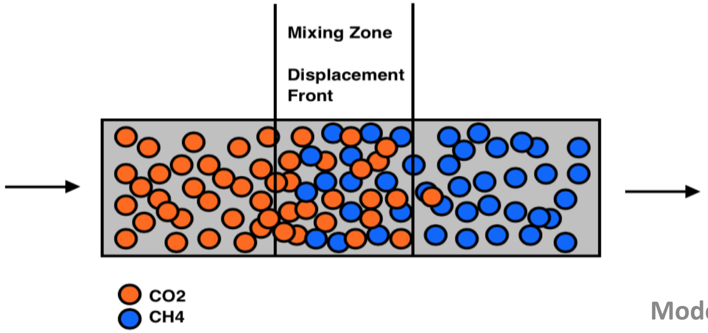
1.0 Introduction

Injection orientation of supercritical CO_2 (SCO_2) during enhanced gas recovery (EGR) and sequestration is one of the key factors to the overall technique in terms of displacement efficiency and extent of gas mixing. Injection orientation plays a vital role in the behaviour of SCO_2 as it traverses the pore spaces of the porous medium during CH_4 displacement at reservoir conditions under gravity. However, the rate of mixing between the injected CO_2 and the displaced CH4 appeared more rapid in the horizontal injection orientation compared to that of vertical injection from previous laboratory tests.

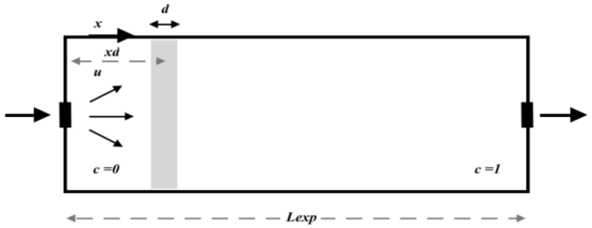
This study aims to investigate the flow behaviour of SCO_2 in a rock core under gravity using a numerical method. The modelling was used to evaluate the gravity effect on the efficiency of CH4 displacement by mimicking a laboratory experimental approach.



2.0 Methodology

2.1 Model assumptions and governing equations

1. CO_2 density ρ and viscosity μ are constant
2. Interstitial velocity u, is constant
3. Porosity ϕ and Permeability k both of with are assumed constant.
4. Dispersion is also assumed to be isotropic throughout the displacement process.
5. Flow is compressible.
6. Temperature is also assumed to be constant.



2.3.1 Brinkman Equation

$$\rho\frac{\partial u}{\partial t} = \nabla\cdot\left[-PI + \mu\frac{1}{\varepsilon}(\nabla u + (\nabla u)^T) - \frac{2}{3}\mu\frac{1}{\varepsilon}(\nabla\cdot u)I\right] - \left(\mu k^{-1} + \beta_F|u| + \frac{Q_m}{\varepsilon^2}\right)u + F + \rho g \quad (1)$$

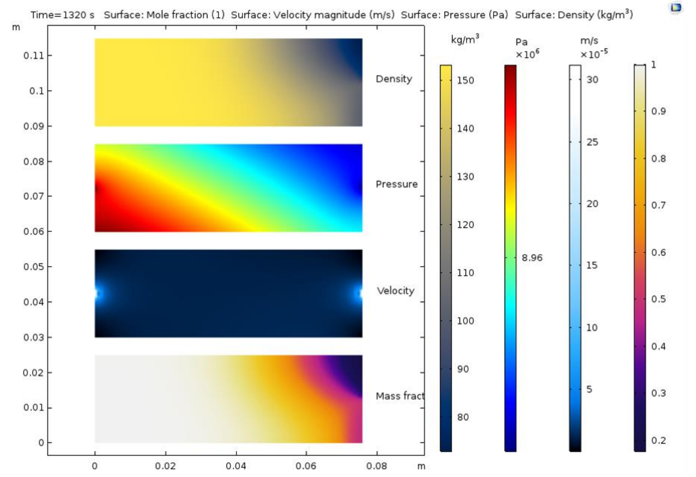
$$Q_m = \frac{\partial\varepsilon\rho}{\partial t} + \nabla\cdot(\rho u) \quad (2)$$

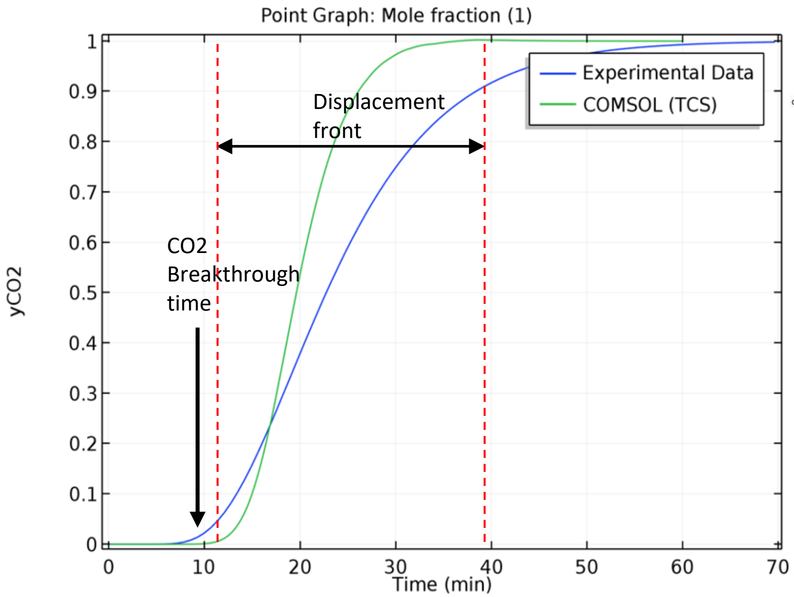
2.3.2 Transport of concentrated species

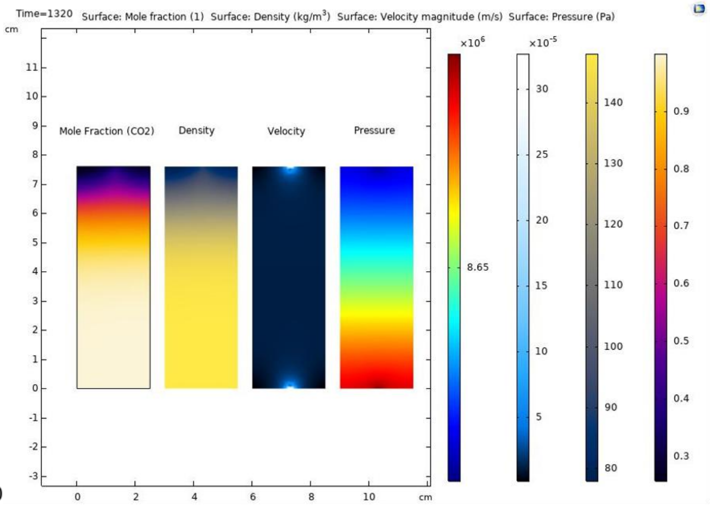
$$\frac{\partial(\rho\omega_i)}{\partial t} + \nabla\cdot j_i + \rho(u\cdot\nabla)\omega_i = R_i \quad (3)$$

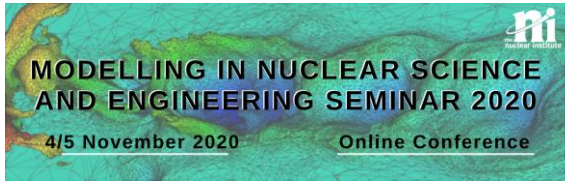
3.0 Results

The results show that gravity contributes significantly to the excessive mixing between CO_2 and CH_4 during the displacement process in the horizonal orientation as it sinks to the bottom of the porous media along the longitudinal axis of the porous medium. This is attributed to the density of the SCO_2 in relation to that of CH_4 at those conditions.









4.0 Conclusion

The numerical results demonstrated a conceivable representation of the laboratory experimental trend obtained for the concentration profiles of CO_2 as it displaced the CH_4. This study explains the reason behind the observation of early breakthrough of CO_2 in the horizontal orientation and subsequent higher mixing between CO_2 and CH_4 compared to the vertical orientation injection.

Acknowledgement

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References

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