A Bundle of Capillary Tubes (BOCT) Model for Carbonated Water Flooding (CWF); a Promising Technique for Simultaneous CO2 Storage and Enhanced Oil Recovery Purposes

Content

Carbonated water flooding (CWF) is a promising technique for EOR and a suitable methodology for permanent geological sequestration of CO2. As carbonated water contacts oil, CO2 preferably diffuses from water into oil, resulting in oil displacement mainly due to oil swelling and viscosity reduction. Moreover, as CO2 remains dissolved in the fluids rather than staying as a free phase, the risk of buoyancy-driven leakage is minimised.

To date, extensive experimental studies have been performed on the EOR and CO2 storage potential of CWF. Nonetheless, due to the complexity of this process, numerical studies on accurate modelling of CWF are limited. Using commercial and in-house simulators, a number of studies have been conducted which exhibit promising results in investigating the underlying mechanisms of this process and predicting experimental observations [1-3]. However, scarcity of experimental data for predicting important parameters and model validation, as well as the intrinsic complexity of the CWF process, cause severe challenges for conducting numerical studies. Accordingly, the deficiencies of previous models, such as over-prediction of oil recovery, unrealistic conditions or materials, over-complex numerical codes, etc. necessitate new avenues of investigation.

Here, we present a convenient, versatile numerical model capable of capturing the complex nature of CWF’s EOR mechanisms with relatively low runtimes. We developed a bundle of capillary tubes (BOCT) model to numerically simulate the results of a previously published experimental study on CWF in core samples [4]. In this numerical study, a pseudo-compositional approach is applied. Firstly, a BOCT model is employed to be a representative of the porous media. Subsequently, the fluid flow equations were derived using momentum balance. Then, through the utilization of a lumped mass transfer approach, CO2 distribution through the media is captured by considering two phases (water and oil) and three components (water, oil, and CO2). Finally, the contribution of CO2 in the EOR process is modelled by using the calculated CO2 distribution throughout the medium and employing valid, widely used correlations.

It was shown that the developed model is adequately capable of matching the oil recovery levels outlined by the experimental results. In addition, sensitivity analyses were performed to investigate the influence of different parameters on oil recovery by CWF and validate the main underlying EOR mechanisms, specifically oil swelling and viscosity reduction. These analyses confirmed oil viscosity and API as the main parameters affecting the performance of the EOR process. Therefore, the BOCT model can be considered as a ‘physical experiment’ and the assessed performance (pressures, flow rates, and production rates) of such ‘samples’ of the porous media as ‘experimental results’. Finally, by using this model to predict the performance of the CWF process, implementing further costly and time-consuming experimental studies to attain direct measurements can be avoided.

Acknowledgement

This project has received funding from the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (MILEPOST, Grant agreement no.: 695070). This paper reflects only the authors’ view and ERC is not responsible for any use that may be made of the information it contains.
References


Acceptance of Terms and Conditions

Click here to agree

Procter and Gamble Student poster award

I would like to compete

Primary authors:  Mr BAKHSHI, Puyan (Heriot-Watt University); Prof. MAROTO-VALER, M. Mercedes (Research Centre for Carbon Solutions (RCCS), School of Engineering and Physical Sciences, Heriot-Watt University, UK); Mr AMANI, Mohammad (Heriot-Watt University)

Presenter:  Mr BAKHSHI, Puyan (Heriot-Watt University)

Track Classification:  MS 7 - (MS7) Mathematical and numerical methods for multi-scale multi-physics, nonlinear coupled processes

Contribution Type:  Poster + 3 Minute Pitch

Submitted by BAKHSHI, Puyan on Friday 06 December 2019