Contribution ID: **550** Type: **Oral Presentation**

Numerical investigation of the flow and phase transitions of CO2 near its triple-point during a blowout from a plugged well

Thursday, 2 June 2022 15:00 (15 minutes)

The dry-ice formation of CO2 near its triple-point can occur during a blowout event in plugged wells, and this process can impact the mass flux of the leaking CO2. From a risk assessment standpoint relating to geologic carbon sequestration, we wish to understand which scenarios will lead to the dry-ice formation, and how this process affects the CO2 flux. In the current work we present a numerical method that can solve for the flow and the supercritical-liquid-gas-solid phase transitions of CO2 over a wide range of pressures.

The first part of the presentation explains the numerical method. Our in-house code solves the compressible 1D Navier Stokes and energy transport equations along with a hybrid equations of state module. To capture any shocks that may occur during the blowout, we use a Godunov-type Riemann-solver based scheme explained in the work of Toro et al. (1994). Our hybrid equations of state comprise of two modules, the first of which covers the gas-liquid-supercritical phase transitions above the triple-point pressure. The second module covers gas-ice and triple-point phase transitions occurring below the triple-point pressure. The former module is an open-source code made available by Fang et al. (2019), and the latter module consists of a Span-Wagner based lookup table that we created by following the work of Hammer et al. (2013). It is important to mention that all phase transitions in the present work are assumed to obey the Homogeneous Equilibrium Model. This model assumes all phases of CO2 at a fixed point in space and time to have the same temperature, pressure, and velocity. In the case of ruptured flow, the outlet pressure is assumed to be atmospheric pressure, unless we observe choked outflow, wherein the speed of CO2 exceeds its speed of sound. In the case of choked outflow, we iteratively determine the outlet pressure such that the resulting outflow has a Mach number of 1. We demonstrate the effectiveness of the numerical method by presenting two benchmark simulations of the shock-tube problem and a simulation of the CO2 leak experiment of Brown et al. (2014).

The second part of this work presents simulations of the blowout from a 1500m deep plugged well that is linked to an infinite reservoir of CO2. The cement plug at the top end of the well ruptures at t = 0, causing a blowout of the CO2. We simulate different reservoir pressures and their impact on the CO2 flux. We also examine the mass fraction of dry-ice at the rupture location and its impact on the leakage flux of CO2. We conclude the presentation by laying out our future work in this project on CO2-hydrate modeling and the related challenges.

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References

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Time Block Preference

Time Block C (18:00-21:00 CET)

Participation

Online

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