Effects of CO_2 binary mixtures on pipeline performance for carbon capture and storage

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ABSTRACT
Captured $CO_2$from the manufacturing industries and power generation sources are not pure and may contain usually some amount of impure components, which affect the flow dynamics of the CO_2 in the pipelines. Major component of impure components includes N_2, H_2, H_2S, O_2, Ar etc., depending on the capture technology used for the removal of CO_2 streams.To design efficient CO_2 pipeline transportation systems, it is imperative to understand the effect of these impure components on the flow behaviour. The simulation of the effect of CO_2 binary mixture on pipeline performance is carried out in this study. The steady-state flow in pipeline is described by a set of parabolic mass, momentum and energy conservation equations. To solve the set of equations subject to the boundary and the inlet conditions of the pipeline, the non-linear algebraic solver library DNSQE in Fortran is used to study the behaviour of 90 vol% CO_2, and 10 vol% single impure component (N_2, H_2, H_2S, $O_2$and Ar). The phase diagram and pertinent fluid properties are calculated using the Peng-Robinson (PR) equation of state implemented in NIST Reference Fluid Thermodynamics and Transport Properties database program REFPROP. The results reveal that the bubble point curves were lifted up to higher pressures by impure components. The changes in the bubble point would affect the operating conditions of CO_2pipeline. The presence of impure components also changed the properties of the flowing fluid. From the results, H_2shows the most significant impact on the performance of CO_2pipeline as the highest pressure drop by ca. 0.18 bar/km which has smaller density and greater flow velocity against other CO_2streams. The results also show that Ar had the mildest effect followed by O_2, $N_2$and CO. In the case of H_2S, the flow parameters are found to be nearly identical to those for pure CO_2. The pressure drop for binary mixture contains H_2S shows the same value with pure CO_2 stream by ca. 0.13 bar/km.

KEYWORDS
Captured CO_2 streams; CO_2 pipeline; Flow behaviour; Impure components; Peng-Robinson equation of state

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