A COMPARISON OF CO_2 AND CO_2 MIXTURE EQUATIONS-OF-STATE IN FITTING P-ρ-T EXPERIMENTAL DATA

Michela Mazzoccoli, Barbara Bosio, Elisabetta Arato
Department of Civil, Environmental and Architectural Engineering, University of Genoa, via Opera Pia, 15, 16145 Genoa, Italy
michela.mazzoccoli@dicat.unige.it

Keywords (Transport, pipeline, thermodynamics, simulation)

The transport is an important feature of the CCS process, indeed sometime indicated as CCS&T (Carbon Capture, Storage and Transportation). In fact, normally the power and industrial production plants that are large sources of CO_2 are located a long distance away from storage locations and the captured CO_2 has to be transported from the point of capture to the storage site. The transport may influence the choice of the capture technology and the limit performance requirements on the basis of the CO_2 quality necessary for the specific transport system, for example in terms of concentration, impurity or pressure and temperature conditions.
Different transport solutions are available, in particular the main ones are pipelines and ships. In any case high density and purity are recommended, while for a safe final storage a CO_2 concentration > 95,5% is required (De Visser et al., 2008).
In this work the attention is focused on pipelines, where CO_2 will most likely be transported at T > 273.15 K and in the pressure range of 80–130 bar: above the critical pressure (73.74 bar), but not too much high in order to avoid the pipeline stress. In these conditions CO_2 is in the "dense" phase and exhibits very low viscosity and a density similar to a liquid allowing smaller pipeline diameter than in the gas phase that presents a very low density.
Moreover, in order to avoid two-phase flow, it is necessary to repump the CO_2 whenever the pressure falls below 80 bar.
Therefore the knowledge of the thermodynamic properties of CO_2 and CO_2-mixtures and the interactions between the CO_2 and other components that it is possible to find (i.e. nitrogen, hydrogen, hydrogen sulphide, methane) could be of great of interest.
For this goal, the study of the Equations of State (EOS) becomes extremely important allowing the thermodynamic property calculations for different mixture compositions in the homogeneous gas, liquid and supercritical region and for vapour-liquid equilibrium (VLE) states.
In addition the EOS are useful to determine, on the basis of operating condition and composition, when a phase change occurs and thus, for example, where it needs a pumping station in order to avoid an excessive pressure decrease. Moreover the EOS can give some information about what can occur as consequence of a pipeline failure.
Therefore, finding a proper Equation of State could be of great of importance in the CCS&T process.
In literature many references are available about CO_2 and CO_2 mixture EOS (Span and Wagner, 1996; Kunz et al., 2007; Li and Yan, 2008; Li and Yan, 2009), nevertheless a suitable equation of state for mixtures in the appropriate conditions for pipeline transport, in particular with a high CO_2 concentration, has not been clearly defined yet.

This paper analyses in detail different EOS (i.e. PR, SRK, RK, BWRS, GERG-2004) in order to evaluate their reliabilities for predicting densities of CO_2 and binary CO_2 mixtures based on the comparisons with experimental data found in literature or obtained by laboratory p-ρ-T measurements.
The comparison among the aforementioned equations of state has been made by means of commercial simulation software such as, for example, Aspen Plus, Aspen Properties, Aspen Hysys and Olga. In this paper the results are shown and discussed in detail.
The aim of this work is to optimize the thermodynamics properties description of CO_2 mixtures, in particular in the crucial working conditions using for the transport.

References

De Visser E., Hendriks C., Barrio M., Mølnvik M.J., De Koeijer G., Liljemark S., Le Gallo Y. (2008). Dynamis CO_2 quality recommendations. International Journal of Greenhouse Gas Control 2, 478-484.
Li H. and Yan J. (2008). Evaluating cubic equations of state for calculation of vapour-liquid equilibrium of CO_2 and CO_2-mixtures for CO_2 capture and storage processes. Applied Energy 86, 826-836.
Li H. and Yan J. (2009). Impacts of equations of state (EOS) and impurities on the volume calculation of CO_2 mixtures in the applications of CO_2 capture and storage (CCS) processes. Applied Energy 86, 2760-2770.
Kunz O., Klimeck R., Wagner W. and Jaeschke M. (2007). The GERG-2004 Wide-Range Equation of State for Natural Gases and Other Mixtures. GERG Technical Monograph.
Span R. and Wagner W. (1996). A New Equation of State for Carbon Dioxide Covering the Fluid region from the Triple-Point Temperature to 1100 K at Pressures up to 800 MPa. J. Phys. Chem. Ref. Data. Vol. 25, N. 6.