A Component Based EoS for the Compressibility Factor of Natural and Sour Gases

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Broadly speaking, estimating techniques for the compressibility factor can be categorized into empirical, correlation, corresponding state, and equation of state methods, with each method showing a varying degree of success with different concentrations of acid gases (nitrogen, carbon dioxide, and hydrogen sulfide). The necessity to be able to predict the compressibility factor at various compositions of carbon dioxide-hydrocarbon mixtures for reservoir models that are designed for qualifying the amount of carbon dioxide that can be stored in the depleted gas and oil reservoirs dictates an improved equation of state technique for the material balance based reservoir simulation models. A four-parameter cubic equation of state is reformed to include a new alpha attractive temperature function that provides an extrapolation of a sub-critical temperature, where the reduced temperature is less than one, to a supercritical temperature, where the reduced temperature is greater than one. The temperature function provides a basis in the theory of the cubic equation of state for an accurate prediction of the PVT properties of the components of reservoir natural gases, sour gases, and gas condensates, without any limitation of the composition of acid gases in the reservoir fluids. The parameters of the equation of state are evaluated in terms of the critical temperature, pressure, critical compressibility factor, and acentric factor of the individual components in the mixture. Eight methods of establishing binary interactions for equations of state are analyzed in terms of the binary species of the measurable properties of pure components, such as boiling point, molecular weight, acentric factor, and critical temperature and pressure.

The reformed equation of state, in comparison with eight equations of state and two z-factor correlations (Standing-Katz and Hall-Yarborough) obtained from the literature, are used to predict various concentrations of carbon-dioxide/hydrocarbon mixtures measured from our PVT laboratory. Gas streams collected from several carbon dioxide pipeline companies and gas plants around west Texas are evaluated with the establish techniques for predicting z-factor. In contrast to the existing correlations, the reformed equation of state provides a universal technique for predicting the z-factor for pure substances, binary mixtures, natural gases, and sour reservoir gases. This paper provides an accurate equation of state method for predicting the compressibility factor of carbon dioxide sequestration in depleted gas and oil reservoirs. The paper is useful for material balance based reservoir compositional models.