Transport Property Equations of State for HFC-245fa

K. Zou and A.S. Lawal[C,S]
Center for Petrophysical and Reservoir Studies, Texas Tech University, Lubbock, TX, U.S.A.
akanni.lawal@ttu.edu

Framework models for estimating the transport properties of hydrocarbon, non-hydrocarbon, polar, non-polar, and refrigerant fluids can be broadly classified into five categories, namely, empirical, semiempirical, group contribution methods, corresponding state models, and theoretical methods. The estimation techniques can further be classified as either correlative (where experimental mixture data are needed) or predictive (where the properties of the pure components constituting a mixture are utilized). Since the literature on the development of predictive techniques for fluid transport properties has revealed the idea of having a predictive cubic equation of state (EoS) as a global transport property framework, this paper takes an approach that is based on the similarity between the graphs of pressure-volume-temperature and temperature-viscosity-pressure (or temperature-thermal conductivity-pressure) to respectively establish a viscosity equation of state (VEoS) and a thermal conductivity equation of state (TCEoS) for refrigerant fluids, particularly R245fa, whose measured viscosity and thermal conductivity data show large uncertainty values.

The respective VEoS and TCEoS is tailored with three temperature related parameters to predict three regions of the R245fa phase diagram, namely, the dilute gas region, the coexistence gas-liquid region, and the supercritical dense-fluid region. The temperature parameters and the input parameters for the equations of state are expressed in terms of the refrigerant's molecular weight and acentric factor, critical temperature, pressure, and compressibility factor. Empirical correlations that are based on the refrigerant's molecular weight, critical temperature, and pressure are utilized to establish the critical viscosity and critical thermal conductivity for the respective VEoS and TCEoS. In lieu of measured critical viscosity and thermal conductivity data, the empirical correlations are validated by resolving the respective equations of state at the fluid critical point, where $T = T_c$ and $P = P_c$. By using the Newton-Raphson technique, a unique critical viscosity (or critical thermal conductivity) that makes two successive guess values to be in the range of 0.0001 of the previously guessed value establishes the critical viscosity (or critical thermal conductivity) for each refrigerant. On the basis of the refrigerant critical parameters, reduced VEoS and TCEoS charts are respectively constructed in terms of the reduced temperature, reduced pressure, and reduced viscosity (or reduced thermal conductivity) for R245fa. The VEoS and TCEoS (critical enhancement is acknowledged through reduced temperature expression) are validated with the limited measured R245fa data reported in the literature. The transport property equations of state are very useful for establishing the pure component viscosity (or pure thermal conductivity) for an empirical mixing rule established for the transport properties of R245fa.