Uncertainty Evaluation of Equations of State for Carbon Dioxide

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Energy-saving refrigeration/air-conditioning systems using non-fluorinated working-fluids are now under development funded by NEDO, the New Energy and Industrial Technology Development Organization, in Japan. In this project, reasonable and reliable thermodynamic property information is very important, not only for the efficient development of equipment, but also as objective performance evaluation criteria for the developed systems. A cycle performance analysis with reliable formulations for thermodynamic properties is especially needed for systems using carbon dioxide, since the operating temperature and pressure conditions are totally different from those in other systems using typical refrigerants.

In the simulation process for these systems, sometimes it is better to use a simple equation of state (EoS) or correlation than to use a complicated EoS, which needs large computing time. A simple equation for a limited range has another merit: that the reproducibility of its thermodynamic property prediction is more apparent than multi-property equations of state.

In the present study, therefore, a set of equations of state, including a saturation property correlation or PVT relation in the single-phase for carbon dioxide, were developed, on the basis of originally evaluated experimental data from literature. We originally estimated a degree of correlation with experimental data, and put it into a covariance matrix used in a least squares fitting. Using this procedure, reasonable values of variance and covariance for optimized parameters were obtained, and we were thus allowed to calculate the uncertainty in the fitted equation.