A New Equation for Predicting the Viscosity of Dense Liquids

Maogang He [C], Ying Zhang [S] and Ying Guo
State Key Laboratory of Multiphase Flow in Power Engineering, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an, Shaanxi, China

The accurate knowledge of viscosity is necessary for industrial design and optimization, establishment of potential energy functions, and the establishment of an accurate theory of viscosity at high density. A large amount of research shows that the mechanics of gas viscosity and the molecular theory have been expounded clearly by non-equilibrium statistical mechanics and kinematics theory of gases, but the theory of liquid viscosity is not mature, and most prediction equations for liquid viscosity are based on empirical models or semi-empirical models. In addition, almost all of the prediction methods of gas viscosity are established on the base of the *Chapman-Enskog* theory or the principle of corresponding states such as the prediction methods of gas viscosity established by *Thodos*(1961), *Lucas*(1980) and C*huang*(1984) et al. The existing prediction methods of the viscosity of dense liquids is mainly based on the Enskog theory or its amendment method and the theory of survival function, such as the methods established by *Chapman*(1939), *Jossi*(1962), *Stiel* and *Thodos*(1964) and Dymond and *Assael*(1996) et al. However, as far as the existing prediction methods of the viscosity are concerned, the error of calculation is often too large to meet the needs of engineering design and the application scope of some methods is often small, for the following reasons: (1) the reproducibility and accuracy of viscosity measurement is lower than that of measurement of equilibrium properties, (2) there is no satisfactory theory for predicting the viscosity of dense liquid, the theories based on the empirical model or semi-empirical model are very limited on the reproducibility and accuracy. In order to describe the viscosity over the entire fluid range, many researchers treat transport properties as a state parameter, dependent on pressure and temperature, or temperature and density. *T. Heckenberger* and *K. Stephan* (1990) found that the shape of isotherm in the diagram of pressure (p) and density (ρ) is very similar to the shape of isotherm in the diagram of pressure (p) and residual transport properties (D*TP*). Based on this research, a large number of researches show that the residual viscosity is only related to the density away from the critical region (*Jossi*, 1962, and *Mao-Gang He*, 2002). So in this work, a virial equation for calculating the viscosity of dense liquid was introduced according to correlating the dimensionless residual viscosity and reduced density. Adopting critical parameter (T_c, P_c), molecular mass (M) and accentric factor (ω) as parameters, the calculation can be accomplished. So the calculation of the viscosity of dense liquid is consistent with the calculation of equilibrium properties perfectly over the entire fluid range.