New Correlation for the Viscosity of Normal Butane

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The exact knowledge of thermophysical properties of fluids with industrial importance is needed for a more accurate basic design of compressors, gas turbines, and gas pipelines. In contrast to thermodynamic properties, transport properties of normal butane, particularly in the region near to the critical point, are not sufficiently well known. In addition, the scientific formulations should guarantee an easy use for an engineer in his daily work. The current NIST standard data base REFPROP 9.1 of Lemmon et al. (2013) recommends the viscosity correlation of Vogel et al. (1999), which is characterized by uncertainties of up to 6% in their range of validity. This viscosity-surface correlation was based on an outdated equation of state of Younglove and Ely from 1987, whereas REFPROP 9.1 recommends the reference equation of state of Bücker and Wagner (2006) for thermodynamic properties of butane.

Recently, new very accurate viscosity measurements were performed by Herrmann and Vogel (2015) using a vibrating-wire viscometer combined with a single-sinker densimeter. The uncertainty of these data was conservatively estimated to be ±(0.25-0.4)%, increasing with temperature. Consequently, they are considered to be primary data. In addition, the increase of the viscosity in the near-critical range can be modeled using appropriate terms described by Vogel et al. (2015) for ethane and Vogel and Herrmann (2016) for propane.

Based on the new reference equation of state and on the improved data situation in the dense-gas region, a new viscosity-surface correlation for normal butane was generated using the structure-optimisation method by Setzmann and Wagner (1989). The bank of terms comprises expressions for different regions: the limit of zero density, the higher-density fluid region, and the near-critical range. Calculated values using the new viscosity-surface correlation were compared with the primary data sets, which were used in the development of the correlation. In addition, the correlated values were compared with values resulting from the earlier viscosity-surface correlations and regarding the extrapolation behavior.