Development of viscosity formulations for working fluids using a structure-optimization method

S. Herrmann[1], H.-J. Kretzschmar[1], E. Vogel[2], K. Meier[3]

[1] *Zittau/Goerlitz University of Applied Sciences, Department of Technical Thermodynamics, Theodor-Koerner-Allee 16, 02763 Zittau, Germany*
E-mail: s.herrmann@hszg.de
[2] *University of Rostock, Institute of Chemistry, Albert-Einstein-Str. 3a, 18059 Rostock, Germany*
[3] *Helmut-Schmidt-University/University of the Federal Armed Forces Hamburg, Institute for Thermodynamics, Holstenhofweg 85, 22043 Hamburg, Germany*

The precise knowledge of thermophysical properties of fluids is required for a more accurate design of steam turbines, pumps, condensers, heat exchangers, and other components of energy and process technology. Furthermore, algorithms have to be adequately provided for the use in engineering calculations. Requirements for property calculations are low uncertainty and high computing speed, which are important in process simulations and online process monitoring in the energy and process industry. Hence, new viscosity formulations for industrially important fluids such as ethane (2015), propane (2016), normal butane (2018), and isobutane (2018) were developed using the structure-optimization method of Setzmann and Wagner (1989).

The concept of the new viscosity formulations for normal butane and isobutane incorporates four contributions: the viscosity in the limit of zero density, the initial-density dependence, the residual contribution, which describes the high-density region, and a contribution, which describes the behavior in the near-critical region. The viscosity in the limit of zero-density is based on experimental data, which were extrapolated to zero density by the authors. It is characterized by a physically correct extrapolation behavior up to 10000 K. The initial density dependence benefitted from the Rainwater-Friend theory for the second viscosity virial coefficient. An approach for the thermodynamic scaling and double polynomials in inverse reduced temperature and reduced density were used for the residual contribution. The critical-enhancement contribution, which was partly pretreated, is modelled by Gaussian bell-shaped terms and is included into the complete formulation. As a result, the formulations for the four alkanes provide a precise representation of the viscosity in the whole fluid region. The new formulations were compared with the primary data sets employed in their development.