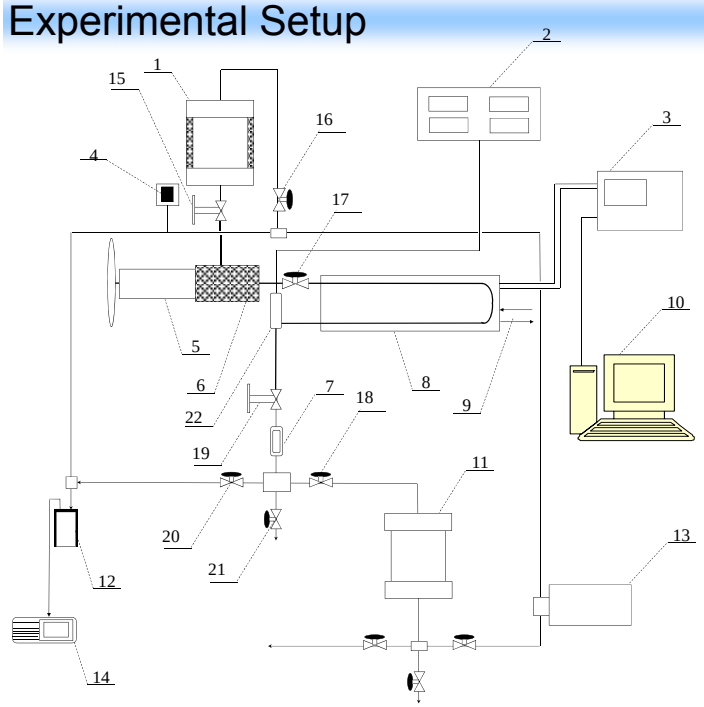
Vibration Tube Densimeter (VTD)

Motivation

The (p, ρ, T) values are needed for the calculation of various thermodynamic properties and development of models:

- data on thermal properties (isothermal compressibility, thermal expansion, excess properties *etc.*)
- calculation of solubility
- basic information for the elaboration of equations of state

Experimental Setup



1 – Input cell for sample; 2 – Pressure / Temperature display; 3 – Anton Paar VTD display; 5 – Hand pump; 6 – Heating; 7 – Vision panel; 8 – Anton Paar VTD; 9 – Connection for the water cooling; 10 – PC; 11 – Input cell for washing fluid; 12 – Cryo trap; 13 – Gear pump; 14 – Vacuum pump; 15, 19 – High pressure valves; 16, 18, 20, 21 – Valves; 17 – Pressure stabilization valve; 22 – Pressure sensor.

Maximum measuring range: p = 35 MPa at T = 623.15 K;
p = 70 MPa at T = 398.15 K.0

Data reduction

The behaviour of the vibrating tube can be described by the simple physical model of undamped spring-mass system. Rearrangement of the model equation and substitution of mechanical constants lead to the classical equation for vibrating tube densimeters:

$$\rho = A - B\tau^2$$

Parameters *A* and *B* are highly temperature and also pressure dependent. The classical equation should be expanded adding temperature- and pressure-dependent terms as follows:

$$A = \sum_0^3 a_i T^i + \sum_1^2 b_i P^i + cTP;\ B = \sum_0^3 d_i T^i + \sum_1^2 e_i P^i + fTP$$

Calibration

Water and methanol were used as reference substances for the evaluation of calibration parameters of VTD installation.

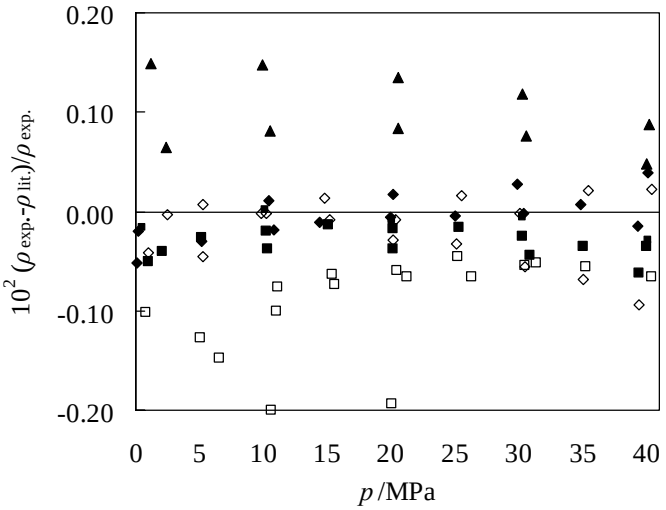


Figure 1. Deviations of experimental density $\rho_{exp.}$ of water and the literature density (IAPWS formulation) $\rho_{lit.}$ versus pressure p (◆ T=298.15 K; ■ T=323.15 K; ▲ 348.15 K; ◇ T=373.15 K; □ T=398.15 K).

Example

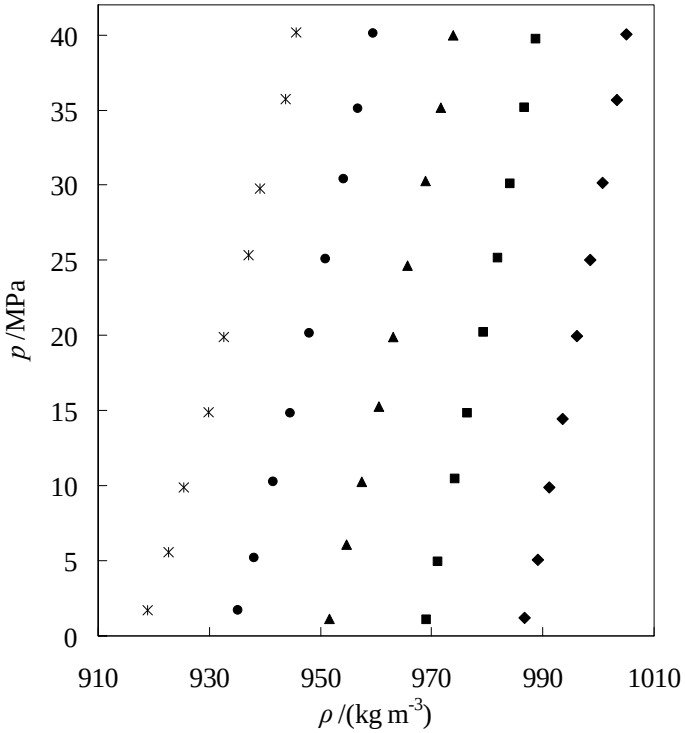


Figure 2. Plot of pressure p versus experimental density $\rho_{exp.}$ of hyperbranched polyester (Boltorn U3000) up to 40 MPa (◆ T=298.15 K; ■ T=323.15 K; ▲ T=348.15 K; ● T=373.15 K; ∗ T=398.15 K).

Contact: liudmila.mokrushina@fau.de