

Czech Society for the Properties of Water and Steam

Annual Report 2020

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Steering board of CZIPWS

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CZIPWS Meetings

Annual meeting of the CZIPWS was held on June 22, 2020. Due to the covid-19 situation, the form of the meeting was electronic. A significant part of the meeting was devoted to CZIPWS funding, in particular to ensuring the membership payments to IAPWS. Payments for 2019 and 2020 are ensured by a national grant led by T. Němec. Despite significant efforts, a long-term funding scheme for IAPWS membership has not yet been ensured.

RESEARCH ACTIVITIES

Surface tension of aqueous systems

The research team at the Institute of Thermomechanics of the Czech Academy of Sciences (IT CAS) obtained new data for the surface tension of supercooled water down to -31.4 °C [1.,4.]. Contrary to previous measurements by Hrubý et al. [J. Phys. Chem. Lett. 5 (2014) 425] and Vinš et al. [J. Phys. Chem. B 119 (2015) 5567], the new data does not refute existence of an anomaly in the temperature trend of surface tension within the deeply supercooled region. An increasing deviation from the IAPWS standard [IAPWS R1-76 (2014)] extrapolated below 0 °C and the new correlation by Pátek et al. [J. Chem. Eng. Data 61 (2016) 928] was detected at temperatures below -25 °C . The motivation for the new experiments carried out with a modified experimental apparatus, allowing for faster measurements at lower temperatures, was to provide an experimental support to the ongoing discussion about the surface tension anomaly, which has been reported recently in several molecular simulations. Possible effect of capillary diameter on the apparent surface tension was studied by R. Mareš and J. Kalová at University of West Bohemia in Pilsen [6.].

Density of aqueous systems

Accurate measurement of the density of IAPWS Standard Seawater were performed in the supercooled and ambient temperature range (253.15 K to 298.15 K) and from atmospheric pressure to 110 MPa using an in-house developed dual-capillary densimeter (DCD). Complementary measurements were performed from 275.15 K to 343.15 K at atmospheric pressure using commercial vibrating tube densimeter (VTD), which was carefully calibrated [5.]. The results were thoroughly compared with the current Release on IAPWS Formulation 2008, IAPWS R13-08. A publication is being prepared.

Densities of aqueous systems with ethylene glycol and glycerol under the atmospheric pressure were measured with VTD. Own calibration procedure of VTD based on the work of Fritz et al. [J. Phys. Chem. B 104 (2000) 15] is being developed in order to obtain accurate and reproducible data over wide temperature range. Density of water + glycerol system, including metastable supercooled region, was also investigated using DCD. Currently, the results of measurements are thoroughly analyzed.

Cavitation

The problems studied in the SIGMA Research and Development Institute and the Centre of Hydraulic Research in the period June 2019 – May 2020 have been related mainly to the application of models of cavitation erosion during the hydrodynamic cavitation (together with the Institute Physics of the Czech Academy of Sciences) and models of cavitation instabilities in hydrodynamic pumps. In cooperation with IT CAS, the Moscow Power Engineering Institute, the Technical University of Liberec, and the Wuhan University, experimental and numerical modelling of unsteady cavitation phenomena in water has continued in the framework of internal grant projects [2.]. In cooperation with IT CAS and the Technical University of Ostrava, experimental and numerical modelling of unsteady multiphase flows has continued, taking into account the interface of water and air [3.].

Other work

A. Blahut participated in the evaluation of “Release on the IAPWS Formulation 2020 on the Viscosity of Heavy Water”.

Publications

1. Vinš V., Hykl J., Hrubý J., Blahut A., Celný D., Čenský M., Prokopová O.: Possible Anomaly in the Surface Tension of Supercooled Water: New Experiments at Extreme Supercooling down to $-31.4\text{ }^{\circ}\text{C}$, Journal of Physical Chemistry Letters 11 (2020) 4443–4447.

Conference Proceedings

2. Sedlář, M., Krátký, T. and Vyroubal, M.: Numerical modelling of three-dimensional cavitating flow considering thermal and compressibility effects. Proc. EFM 2019, Franzenbad, 2019, to be published in EJP Web of Conf.
3. Sedlář, M., Machalka, J. and Komárek, M.: Modeling and optimization of multiphase flow in pump station. Proc. CSMO 2020, Xi'an, 2020, to be published in Journal of Physics.
4. Vinš V.: IAPWS Helmholtz Award Lecture - Surface Tension of Water, Seawater and Aqueous Binaries at Low Temperatures including Metastable Supercooled Region, IAPWS Symposium - Chemistry and Mass Transport for Steam Generation, Banff, Alberta, Canada, October 2, 2019.
5. Prokopová O., Blahut A., Čenský M., Vinš V.: Comments on water & air calibration of vibrating-tube densimeter at atmospheric pressure, Proceedings of the int. conf. Experimental Fluid Mechanics 2019, November 19-22, 2020, Franzensbad, Czech Rep. p. 400-407.
6. Kalová J., Mareš R., Size dependences of surface tension and measurement accuracy, AIP Conference Proceedings 2189, 020010 (2019)