

Czech Society for the Properties of Water and Steam

Annual Report 2021

Submitted to IAPWS Executive Committee, September 2021

Steering board of CZPWS

Chair: Tomáš Němec (Institute of Thermomechanics of the Czech Academy of Sciences - IT CAS, nemec@it.cas.cz), Vice-Chair: Josef Šedlbauer (Technical University of Liberec), Secretary: Jan Hrubý (IT CAS), Member: Radim Mareš (University of West Bohemia), Member: Milan Sedlář (SIGMA Research and Development Institute).

CZPWS Meetings

Annual meeting of the CZPWS was held on June 23, 2021. Due to the covid-19 situation, the form of the meeting was electronic. CZPWS members were informed about the activities of CZPWS Chair and approved CZPWS Financial Statements. The 2021 payment of CZPWS Member Due to IAPWS was provided from a national grant led by T. Němec. In 2021, CZPWS became a member of the Council of Scientific Societies of the Czech Republic (RVS – <http://rvs.paleontologie.cz>). Future CZPWS Member Dues to IAPWS will be paid based on the CZPWS membership in RVS. The process of enrolling CZPWS into RVS was long and required significant efforts primarily from the side of CZPWS Chair.

RESEARCH ACTIVITIES

Surface tension of aqueous systems

Experimentalists from IT CAS in Prague continued an investigation of the surface tension of aqueous systems at low temperatures, including the supercooled metastable state. Preliminary data for the surface tension of water + ethylene glycol were presented at the 21st Symposium on Thermophysical Properties held in Boulder (USA) in June 2021 [10.]. The team also developed own calibration technique based on the work of Fritz et al. [J. Phys. Chem. B 104 (2000) 15] for a highly sensitive commercial instrument – the vibrating tube densimeter Anton Paar DMA 5000 M. The results for air + water calibration and a series of reference liquids with various viscosities were also presented at the Boulder conference [11.] and are being prepared for a journal publication.

Recent work on surface tension of supercooled water at University of West Bohemia in Pilsen was reported by R. Mareš and J. Kalová [1.]. The Pilsen group used the capillary rise method and measured the surface tension of water down to – 32.27 °C. It is shown in the paper that results of experiments do not confirm the existence of second inflection point in the deeply supercooled water.

Nucleation and condensation

M. Šťastný (University of West Bohemia in Pilsen) published a broad review of steam condensation in nozzles and turbines a form of a book chapter [2.] and a textbook [3.].

J. Hrubý (IT CAS) participated in the research of nucleation of droplets in the water – sulfuric acid system [4.]. In collaboration with group of V. Ždímal (Institute of Chemical Process Fundamentals of the Czech Acad. Sci.), a new device was developed and the corresponding mathematical models were tested. J. Hrubý continued in the research of the effect of carrier gases on nucleation of water droplets in collaboration with group of D. Smeulders (Eindhoven University of Technology, Netherlands). Recent work focused on water nucleation in mixtures with carbon dioxide and nitrogen at various mixing ratios and various pressures [5.].

Cavitation

The problems studied in the SIGMA Research and Development Institute and the Centre of Hydraulic Research in the period of June 2020 – June 2021 have been related mainly to the modelling of cavitation erosion during the hydrodynamic cavitation and models of cavitation instabilities. In cooperation with the Institute of Physics of the Czech Acad. Sci., a new cavitation erosion stand has been put into operation. In cooperation with the Moscow Power Engineering Institute, the Technical University of Liberec and the Wuhan University, the experimental and numerical modelling of unsteady cavitation phenomena in water has continued in the framework of internal grant projects. The experiments and numerical simulations have concentrated on the thermal effects of cavitation and on the influence of surface hydrophobicity on cavitation phenomena [6.]. In cooperation with IT CAS and the Technical University of Ostrava, the experimental and numerical modelling of unsteady multiphase flow has continued, taking into account the interface of water and air [7.].

Other work

A. Blahut (IT CAS) served in an evaluation task group in the evaluation of proposed IAPWS formulations on the viscosity of heavy water [(IAPWS R17-20, Release on the IAPWS Formulation 2020 for the Viscosity of Heavy Water (2020)] and on thermal conductivity of heavy water [IAPWS R18-21, Release on the IAPWS Formulation 2021 for the Thermal Conductivity of Heavy Water (2021)].

Publications

1. Kalová J., Mareš R.: Surface Tension in the Supercooled Water Region, *Int. J. of Thermophysics* 42 (2021) 131, <https://doi.org/10.1007/s10765-021-02884-z>
2. Šťastný M.: *New Ideas Concerning Science and Technology*, Vol.4, Chapter 1, Investigation on Losses Connected with Steam Condensation in Turbine Cascades, Book Publisher International, India+United Kingdom, 2021, ISBN 978-81-949988-9-1.
3. Šťastný M.: *Condensation of Steam in Nozzles and Turbine Cascades*. ZČU, Fakulta strojní, Plzeň, 2015, ISBN 978-80-261-0489-6.
4. Trávníčková T., Havlica J., Kozakovic M., Hrubý J., Ždímal V.: Derivation and validation of a simplified analytical mass transfer model of the laminar co-flow tube for nucleation studies. *Int. J. Heat and Mass Transfer* 179 (2021) 121705. <https://doi.org/10.1016/j.ijheatmasstransfer.2021.121705>
5. Campagna M.M., Hrubý J., van Dongen M. E. H., and Smeulders D. M. J.: Homogeneous water nucleation in carbon dioxide – nitrogen mixtures: Experimental study on pressure and carrier gas effects. *J. Chem. Phys.* 154 (2021) 154301 <https://doi.org/10.1063/5.0044898>
6. Sedlář M., Komárek M., Šoukal J., Volkov A.V., Ryzhenkov A.V., Naumov A.V., Druzhinin A.A., Vikhlyantsev A.A.: *Experimental and Numerical Investigation of Impacts of Cavitation on Hydrofoils with Treated Surfaces*. *Thermal Engineering*, submitted June 2021

7. Sedlář M., Machalka J., Komárek M.: Modeling and Optimization of Multiphase Flow in Pump Station. *Journal of Physics*, 1584 (2020), 012070. doi:10.1088/1742-6596/1584/1/012070
8. Sedlář M., Procházka P., Komárek M., Uruba V., Skála V.: Experimental Research and Numerical Analysis of Flow Phenomena in Discharge Object with Siphon. *Water* 12 (2020) 3330. doi:10.3390/w12123330
9. Furst J., Halada T., Sedlář M., Krátký T., Procházka P., Komárek M.: Numerical analysis of flow phenomena in discharge object with siphon using lattice-Boltzmann method and CFD. *Mathematics*, submitted June 2021

Conference Proceedings

10. Vinš V., Hykl J., Prokopová O., Gatter J., Klomfar J., Součková M., Čenský M., Blahut A.: Surface tension and density of water + ethylene glycol mixtures at low temperatures including metastable supercooled state, 21st Symposium on Thermophysical Properties, Boulder, Colorado, 20-25 June 2021.
11. Prokopová O., Blahut A., Čenský M., Součková M., Vinš V.: Water & air calibration of vibrating-tube densimeter at temperatures from 0 to 90 °C and atmospheric pressure. 21st Symposium on Thermophysical Properties, Boulder, Colorado, 20-25 June 2021.

Ing. Jan Hrubý, CSc.

Scientific secretary of CZPWS