

研究・教育活動報告書/Research and Educational Activities Report

Physical modelling of transport phenomena within engineering thermal systems

Research effort has been dedicated to the application of thermodynamic variational principles for the mathematical formulations of engineering phenomena recurrent in thermal systems. Specifically, the Principle of minimum energy and Prigogine's Theorem of minimum entropy generation to Falling film wetting [1] and two-phase refrigerant distribution in microchannel heat exchangers [2][6], respectively. In parallel, an Artificial Intelligence approach has been investigated on the latter phenomenon and reverse network explored for device optimization procedures [3]. Genetic Algorithm has been implemented for circuitry optimization in finned-tube heat exchangers [7] [8] and system-scale optimal operation [4]. A simplified formulation through Taylor series approximation was implemented as the mathematical framework for modelling open refrigerated display cabinets in combination with the representation given by collected experimental data [5]. Other semi-theoretical models were obtained for desiccant wetting [9] and two-phase flow void fraction [10]. The international collaboration with Prof. Felix Ziegler (TUB) and Prof. Alberto Coronas (Universitat Rovira i Virgili) has resulted in a final draft of a review paper on Absorption Heat Transformers, which is being internally reviewed and will be submitted during the second year at WIAS.

Given the shared effort in a generalized formulation of irreversible processes within non-equilibrium Thermodynamics, research collaboration has been started with Prof. Hiroaki Yoshimura at the Dept. of Applied Mech. and Aerospace Eng. First general modelling efforts carried out this year will be the basis for achieving a unifying formulation of the phenomena of interest for thermal systems and for expressing the mathematical framework of semi-empirical models obtained in combination with experimental measurements gathered in collaboration with Prof. Kiyoshi Saito (Dept. of Applied Mech. and Aerospace Eng.).

Journal publications

- [1] ○ “Film rupture and partial wetting over flat surfaces with variable distributor width”, *Science and Technology for the Built Environment*, 25:10, 2019, 1313-1324, DOI: [10.1080/23744731.2019.1648982](https://doi.org/10.1080/23744731.2019.1648982).
- [2] ○ “Characterization of two-phase flow distribution in microchannel heat exchanger header for air-conditioning system”, *Experimental Thermal and Fluid Science*, 106, 2019, 183-193, ISSN 0894-1777.
- [3] ○ “Prediction of two-phase flow distribution in microchannel heat exchangers using artificial neural network”, *International Journal of Refrigeration*, 111, 2020, 53-62, ISSN 0140-7007.
- [4] ○ “Optimization of HVAC system energy consumption in a building using artificial neural network and multi-objective genetic algorithm”, *Sustainable Energy Technologies and Assessments*, 35, 2019, 48-57, ISSN 2213-1388.
- [5] ○ “Seasonal performance evaluation of CO₂ open refrigerated display cabinets”, *Applied Thermal Engineering*, 163, 2019, 114354, ISSN 1359-4311.

Conference presentations

- [6] ○ “Numerical simulations of finned-tube heat exchangers with arbitrary connectivity and flexible set of input conditions”, The 5th International Symposium on Innovative Materials and Processes in Energy Systems, Kanazawa Japan.
- [7] “Development of finned-tube heat exchanger simulator for heat pumps”, International Workshop on

Environmental Engineering 2019, Okinawa, Japan

[8] “Theoretical formulation of two-phase flow distribution in microchannel heat exchangers using electric circuit analogy”, International Workshop on Environmental Engineering 2019, Okinawa, Japan.

[9] ○ “Semi-theoretical model of ionic liquid wetting characteristics on a gas-liquid finned-tube contactor”, 25th IIR International Congress of Refrigeration 2019, Montreal, Canada.

[10] ○ “Semi-Theoretical Formulation of Annular Flow Void-Fraction”, 11th International Meeting on Advances in Thermofluids 2019, Kyushu University, (Japan)

[11] ○ “A practical heat and mass transfer model between air and ionic liquid solution in an internally cooled dehumidifier with partial wetting”, 25th IIR International Congress of Refrigeration 2019, Montreal, (Canada).

[12] ○ “Comparative analysis of ionic liquids as sorptive media for absorption systems”, 25th IIR International Congress of Refrigeration 2019, Montreal, (Canada).

[13] “膨張弁における混合冷媒流れの数値解析” (Numerical investigation of mixed refrigerants flow in the expansion valve), 2019 年度日本冷凍空調学会, 東京 (日本).

[14] “低 GWP 冷媒を採用した次世代冷凍空調技術の実用化評価に関する研究開発第 1 報 : 次世代低 GWP 冷媒のサイクル性能評価研究の概要と 2018 年度の取り組み“(Development of assessment techniques for next-generation refrigerants with low GWP values; 1st report: Outline of the research cycle performance evaluation for next-generation refrigerants with low GWP and the approach in 2018), 2019 年度日本冷凍空調学会, 東京 (日本).