研究・教育活動報告書/Research and Educational Activities Report
Physical modelling of transport phenomena within engineering thermal systems

This year's effort in the modelling of transport phenomena within engineering thermal systems was directed to the formulation of two-phase flow distribution and void fraction. The variational formulation of two-phase refrigerant distribution was finalized in two journal manuscripts: the first presented the theoretical formulation and is presently under review, whereas the second applied the general theory to the specific case of microchannel heat exchangers while providing an experimental validation of the model (to be submitted during the next academic year). Additionally, the variational formulation of two-phase void fraction [2.1-2.2] was extended to non-equilibrium circumstances, while including heat and mass transfer between phases as well as capillary effects.
In parallel, the interdisciplinary implementation of Artificial Intelligence and fundamental theory of thermal systems has resulted into the development of a cost-effective method for system characterization [2.3-2.4], which will be used for field application and, eventually, for optimizing system control.
The international collaboration with Prof. Felix Ziegler (TUB) and Prof. Alberto Coronas (Universitat Rovira i Virgili) has resulted in the publication [2.5] of a review paper on Absorption Heat Transformers on the highest-impact-factor journal in the field (Renewable and Sustainable Energy Reviews). Additionally, the collaboration is presently continuing for the characterization of high-temperature Marangoni convection and film wettability in falling film absorbers. The progress of these topics is to be presented at the ISHPC2021 in Berlin (Germany) and consequently expounded for targeting a journal publication in the International J. of Refrigeration.
The collaboration with Ass. Prof. Liang Li, (University of Hertfordshire, UK) has led to a first draft of a joint publication on the modelling of R32 heat pump water heaters to be submitted during the next academic year.
The results of the international collaboration with the University of Florence on the development of natural refrigerant technologies (specifically the use of air as a refrigerant in an asynchronous air-refrigeration-cycle with energy storage and high-temperature falling film absorption) have been presented at the IIR (International Institute of Refrigeration) Gustav Lorentzen Conference on Natural refrigerants [2.6-2.7] and will be expounded in a journal publication to be submitted during the next academic year.

Journal papers (2020)
[2.1] ○(lead author) "Semitheoretical formulation of annular flow void fraction using the principle of minimum entropy production", *International Journal of Thermal Sciences*, 158, 2020, 106522.
[2.2] ○ (lead author) "Formulation of steady-state void fraction through the principle of minimum entropy production", *Journal of Thermal Science and Technology*, 15(3), 2020, 1–13, 20-00304.
[2.3] ○ "A cost effective and non-intrusive method for performance prediction of air conditioners under fouling and leakage effect", *Sustainable Energy Technologies and Assessments*, 42, 2020, 100856.
[2.4] ○ "Experimental implementation of artificial neural network for cost effective and non-intrusive performance estimation of air conditioning systems", *Applied Thermal Engineering*, 181, 2020, 115985.
[2.5] ○ "Absorption heat transformer - state-of-the-art of industrial applications", *Renewable and Sustainable Energy Reviews*, 141, 2021, 110757.

Conference papers (2020)
[2.6] ○ "Assessment of surfactant-induced Marangoni convection within high-temperature aqueous Lithium-Bromide solution", The 14th IIR Gustav Lorentzen Conference on Natural refrigerants, (December 7th – 9th, 2020) Kyoto, Japan.
[2.7] ○ "Thermodynamic investigation of asynchronous open inverse air cycle integrated with compressed air energy storage", The 14th IIR Gustav Lorentzen Conference on Natural refrigerants, (December 7th – 9th, 2020) Kyoto, Japan.
[2.8] ○ "Experimental performance analysis and simulation of an internally cooled liquid desiccant air

conditioning system using a novel ionic liquid", The 14th IIR Gustav Lorentzen Conference on Natural refrigerants, (December 7th – 9th, 2020) Kyoto, Japan.
[2.9] ○ "Numerical Investigation of CO2 Heat Pump Water Heater Performance", The 14th IIR Gustav Lorentzen Conference on Natural refrigerants, (December 7th – 9th, 2020) Kyoto, Japan.
[2.10] ○ "Flow Characteristics and Noise Diagnosis of Hydrogen Charging Solenoid Valve in Hydrogen-Fueled automobile", The 33rd International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, (June 29th-July 3rd, 2020) Osaka, Japan.
[2.11] "低 GWP 冷媒の実用化に向けたシミュレーションによる圧縮機の性能評価; 第 1 報：漏れと熱伝達を考慮したスクロール圧縮機モデル" (Evaluating Compressor Performance by Simulation for practical use of low-GWP refrigerants; 1st Report : scroll compressor model of leakage and heat transfer), 2020 年度日本冷凍空調学会年次大会講演論文集（2020.9.8-11，津）(日本).
[2.12] "マイクロチャンネル熱交換器の最適設計に関する研究" (Optimal Design of Microchannel Heat Exchanger), 2020 年度日本冷凍空調学会年次大会講演論文集（2020.9.8-11，津）(日本).