editorial

Heat Transfer, Fluid Mechanics and Thermodynamics in Industry – HEFAT2011

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This editorial provides an overview of a special issue dedicated to the 8th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics – HEFAT2011 – hosted in Mauritius. All papers for this conference were peer-reviewed and almost 150 papers were accepted. Of these, nine were selected for this issue and peer-reviewed for a second time according to journal standards. The nine papers focus on recent developments regarding heat transfer in industry and include the acidity and method of preparation of nanofluids nucleate pool boiling; industrial boiler circulation; spray cooling of electronic components; freezing in a horizontal plate freezer with CO_2 as refrigerant in a cascade refrigeration system; thermal simulation of a pulsing heat pipe; condensation of R22 retrofits; vertically downward-blowing single-jet air curtains in cold rooms; gravity-assisted heat pipe air-to-air cooler; forced convection in curved ducts; and flow in the transitional flow regime. The current issue of Heat Transfer Engineering *is the eighth special journal issue dedicated to selected papers from the HEFAT conferences.*

INTRODUCTION

In industry, heat transfer, fluid mechanics and thermodynamics are used as engineering sciences to enhance our basic understanding and design capabilities [1] of a broad range of phenomena [2-10], equipment [11-13], applications [14-15] and systems [16-17] ranging from biological systems [18-19] to common household appliances [20-21], aerospace [22-23], residential and commercial buildings [24-25], mining [26-27], industrial processes [28-29], and electronic devices [30-31]. These disciplines–can also be used to conduct techno-economic analyses [32-39] for comparing different types of equipment and systems, so as to allow decisions in terms of capital and running costs in comparison to the cost of financing and impact on the environment [40-41]. For this reason, various conferences are held annually to encourage closer collaboration and allow people from all over the world to share information and create opportunities for collaboration.

The series of HEFAT (Heat Transfer, Fluid Mechanics and Thermodynamics) conferences is one of many such opportunities. In 2002, the 1st International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2002) was hosted in the Kruger National Park, South Africa. The 2nd International Conference (HEFAT2003) was hosted at the Victoria Falls, Zambia in 2003. HEFAT2004 was held in Cape Town, and the 4th and 5th conferences took place in Cairo and at Sun City, South Africa, respectively. HEFAT2008 (the 6th International Conference) was held in Pretoria, South Africa and formed part of the University of Pretoria's 100-year celebrations, "A century in the service of knowledge". The 7th conference in the series (HEFAT2010) was held in Antalya, Turkey in 2010 and the 8th one, HEFAT2011 (to which this issue is dedicated), took place in Mauritius from 11 to 13 July 2011. A total number of 150 papers were read over this period, which include seven keynote papers.

Mauritius is located approximately 2 000 km off the south eastern coast of Africa and lies east of Madagascar in the midst of the Indian Ocean. The country covers an area of 1865 km^2 with 330 km of coastline. Surrounded by one of the longest continuous coral reefs in the world, the miles of fine, sandy beaches are lapped by clear, turquoise waters. Mauritius is a blend of diverse cultures and religions which its immigrant population brought from their ancestral countries. Their festivities are celebrated in a spirit of peace and harmony throughout the year. The island is one of the world's most sought-after destinations and a popular environment for conferences and exhibitions.

The purpose of the HEFAT conferences is to provide a forum at which specialists in heat transfer, fluid mechanics and thermodynamics from all corners of the globe may present the latest progress and developments in the field. The conferences have also served as a catalyst for discussions on future directions and priorities in the areas of heat transfer, fluid mechanics and thermodynamics. Significant contributions have been made directly and indirectly to the challenges of society in terms of energy efficiency, global warming, greenhouse gas emissions, pollution and effluents.

SELECTED CONTRIBUTIONS

After every HEFAT conference, a special issue with selected papers is published in *Heat Transfer Engineering*. So far seven issues [42-48] have been published and it gives me great pleasure to hereby present the eighth special issue. As with past conferences, the session chairs and co-chairs were asked to identify the best paper of each session and the nine best papers (which includes one keynote paper) in heat transfer were considered for this special issue. Each was reviewed again by a minimum of two reviewers. The current edition therefore covers the best papers of the HEFAT2011 conference held in Mauritius, dealing with various aspects of heat transfer engineering in industry. They discuss a wide range of heat transfer engineering aspects that include the acidity and method of preparation of nanofluids nucleate pool boiling; industrial boiler circulation; spray cooling of electronic components; freezing in a horizontal plate freezer with CO_2 as refrigerant in a cascade refrigeration system; thermal simulation of a pulsing heat pipe, condensation of R22 retrofits; vertically downward-blowing single-jet air curtains in cold rooms; gravity-assisted heat pipe air-to-air cooler; and forced convection in curved ducts.

The first article experimentally investigated frost growth on microgrooved and flat brass samples under specific operating conditions and compared the condensation, frosting and defrosting pattern on microgrooved and flat brass surfaces. The surfaces that were used in the experiments were fabricated by a mechanical micro-machining process and no chemical alteration of the surface was conducted. It was found that the shape, size and distribution of condensed water droplets and the subsequent frost structure were significantly affected by the presence of microgrooves on the surface. The frost crystals exhibited more directional growth parallel to the surface, with numerous ice-flakes growing in the perpendicular and angular directions to the grooves. Qualitative and quantitative studies of the spatial and temporal distribution of retained frost melt-water on the grooved and flat brass surfaces were carried out by means of thermal imaging. Some preliminary results of this analysis were reported, which can serve as a basis for developing a frost melt-water retention model in the future.

The second article considered Large Eddy Simulation (LES) combustion modeling and the validation of models in non-premixed and premixed situations. Two well-defined experimental configurations where high quality data was available for validation were considered as case studies to demonstrate the methods accuracy and capability of the LES combustion modeling technique as a predictive tool. The LES technique for the modeling of flow and turbulence is based on the solution of governing equations for continuity and momentum. The Smagorinsky eddy viscosity model with a localized dynamic procedure was used as the sub-grid scale turbulence model. A swirl flame was considered as the non-premixed combustion application. A model based on dynamic flame surface density was used for premixed combustion. It was shown that in both cases LES-based combustion models performed remarkably well and the results agreed well with the experimental data.

Nanoparticle-related heat transfer phenomena and their application in biomedical fields were described in the third paper. Over the past decade, interests in the synthesis and application of nanomaterials in different fields extended from the energy to biomedicine sectors. Several biomedical applications involve delivering bio-modified nanoparticles to malignant cells and rapidly heating nanoparticles with an external source such as laser, ultrasound or an electromagnetic wave to produce a therapeutic effect or to release drugs. The interaction of nanoparticles with the external source and the subsequent heating effect are fundamental for the successful deployment of these novel techniques. Some initial theoretical and experimental studies were conducted to reveal the potentials of this exciting field. The combination of gold nanoparticles with ultrasound irradiation or electromagnetic waves at the radiofrequency spectrum was shown to be a promising strategy for future medical applications. Further understanding of the heating of nanoparticles in-situ and thermal response at nanoscale (which is essential for successful medical applications) calls for cross-disciplinary collaboration among engineers, scientists and clinicians.

The fourth paper deals with heat rejection in condensers close to the critical point. Usually three zones are assumed in the modeling of condensers: de-superheating, condensation and subcooling, even though condensation occurs in the de-superheating zone during some conditions and subcooling occurs during condensation. This paper discusses the actual situation and provides experimental validation. The experimental results give heat transfer coefficients of CO_2 and R410A at mass fluxes from 100 to 240 $kg/m^2.s$, heat fluxes from 3 to 25 kW/m^2 and reduced pressures from 0.68 to 1.0 in a horizontal smooth tube of 6.1 mm inner diameter. Data is compared to correlations proposed for other working fluids or other conditions. The results suggest that simplified calculations of heat rejection in the superheated zone could oversize condenses. A semi-empirical correlation is proposed as the combination of existing correlations for single-phase turbulent and saturated condensation, which satisfactorily predicts the heat transfer coefficients of condensation in the superheated zone.

The dependence between water and energy in industry and the way these resources can be managed in an integrated and more sustainable manner are dealt with in the fifth paper. The fundamental methodology that supports the concept of simultaneous management of water and energy is the process system approach, which is guided by a deep understanding of simultaneous mass and heat transfer, considering phase and pressure changes. In this paper special attention is paid to the utilization of the latent heat of water evaporation and condensation, which allows for water and heat recycling. The paper takes a new view on water solutions management, especially when processes experience difficulties for direct heat recovery. The advantages of water saving, efficiency improvement, and the improved environmental impact of proposed solutions were studied and established in an industrial situation.

The sixth paper reports on the influence of the geometry of open-cell aluminum foam on the thermo-hydraulic behavior in channel flow. A numerical model was implemented in a commercial solver, based on volume averaging theory that was validated against experimental data. The thermo-hydraulic characteristics of 16 well-chosen foams were used to build a surrogate model based on a Kriging model. It was found that the relative increment of the pressure drop is an order of magnitude higher than the increment observed for heat transfer and that an applied performance evaluation criterion was mainly influenced by the hydraulic performance. For a given application, a clear optimum was found. The proposed method in the paper allowed for the performance of the parameter study with acceptable computational cost and a sufficient level of detail from an engineering perspective.

The effect that two different mesh grids have on the structure of the mixing layer of an axisymmetric jet was studied in the seventh paper. Detailed measurements of mean velocity and turbulent velocity fluctuations were made with a hot wire probe. The grids were introduced at two locations: one location just downstream of the nozzle exit plane and the other location upstream of the nozzle exit plane in order to perturb the nozzle exit boundary layer. One mesh completely covered the nozzle and the other mesh covered the central high-speed zone. It was found that the third-order energy transfer term is affected in such a way that, relative to the undisturbed jet, its peal location was shifted to a smaller scale with the full mesh being used and to a larger scale with the disk mesh. This is consistent with the author’s observations that the full mesh reduced the turbulence in the shear layer, whereas the disk mesh enhanced it. Furthermore, it is suggested that the large-scale vortices that were formed at the edge of the grids play a significant role in the transfer of energy.

The eighth paper deals with the LIVE program at the Karlsruhe Institute of Technology and investigates core melt. The latter is considered experimentally both in a large-scale three-dimensional geometry and in supporting separate-effects tests. Numerical codes were used in order to provide a reasonable estimation of the remaining uncertainty band under the aspect of safety assessment. Within the LIVE experimental program, several tests were performed with water and with non-eutectic fluids. The results of these experiments that were performed in nearly adiabatic and isothermal conditions, allow a direct comparison with findings obtained earlier in other experimental programs and will be used to assess the correlations derived for the molten pool behavior.

The ninth paper is dedicated to the unique fluid flow characteristics and associated forced convection in curved ducts where the flow behavior is typified by counter-rotating secondary flow vortices arising from the centrifugal forces due to flow curvature. If flow is laminar and developing through curved heated ducts, this study formulated a novel three dimensional computational fluid dynamics model, based on vortex structures or helicity. The fluid and thermal characteristics were examined by using helicity contours in duct cross sections for a range of flow rates, wall heat fluxes and duct aspect ratios at selected duct curvatures. Curved ducts of rectangular and elliptical cross sections were analyzed to identify and compare the fundamental differences in flow characteristics for each duct type. The study also presents a new technique using dimensionless helicity for detecting the onset of hydrodynamic instability in curved ducts. Numerical predictions of the study were validated with experimental data. It was observed that with increased duct flow rate, the secondary flow intensifies. Beyond a certain critical flow condition, it leads to hydrodynamic instability in both types of ducts. However, the overall fluid flow structure, hydrodynamic instability and forced convection are significantly dependent on the type of duct, while these aspects were also significantly influenced by the duct aspect ratio and wall heating.

The conference organizers are grateful to all who enthusiastically contributed to the conference. Special thanks are due to the authors of the papers in this special issue, who worked diligently in meeting the review schedule and responding to the reviewers' comments. As always, the reviewers played an important role in improving the quality of the papers and I have great appreciation for the very thorough reviews that were received. Feedback from a minimum of two reviewers was used as acceptance criteria.

Last but not least I would like to thank Professor Afshin Ghajar, the Editor-in-Chief of *Heat Transfer Engineering,* for his dedication and willingness to publish this series of special issues highlighting the current research going on worldwide. He has been a major supporter of the special issues and I am indebted to him.

CONCLUSION

I believe that the articles in this special issue of *Heat Transfer Engineering* make a significant contribution to the heat transfer challenges of society; also, that it will increase an awareness about and the international reputation of the HEFAT conferences. The next special issue will reflect the activities of the HEFAT2012 conference held in Malta.

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