editorial

Heat Transfer, Fluid Mechanics and Thermodynamics in our Environment – HEFAT2012

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This editorial provides an overview of a special issue dedicated to the 9th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics – HEFAT2012 – hosted on Malta. All papers for this conference were peer-reviewed and 270 papers were accepted. Of these, 10 of the best papers were selected for this issue and peer-reviewed for a second time according to journal standards. The 10 papers focus on the characteristics of oxyfuel and air-fuel combustion in an industrial water tube boiler, numerical and optical analysis of a weather-adaptable solar reactor, the mitigation of crystallisation fouling using projectiles in tubular heat exchangers, the mitigation of crystallisation fouling in a single heated tube using projectiles of different sizes and hardness, a framework for the analysis of thermal losses in reciprocating compressors and expanders, an annular impinging jet controlled by radial synthetic jets, multi-effect plants and ionic liquids for improved absorption chillers, the effect of climatic parameters on the heat transfer mechanisms in a solar distillation still, empirical correlations for slightly decaying grid turbulence, and pool boiling on modified surfaces using R-123. The current issue of Heat Transfer Engineering is the ninth special journal issue dedicated to selected papers from the HEFAT conferences.

INTRODUCTION

In industry, heat transfer, fluid mechanics and thermodynamics are used in environmental studies 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 to allow decisions in terms of capital and running costs in comparison with 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, the 8th one

(HEFAT2011) was held on Mauritius and HEFAT2012 (to which this issue is dedicated) took place on Malta from 16 to 18 July 2012. A total of 270 papers were read over this period, including six keynote papers.

The island of Malta is a small independent nation state in the centre of the Mediterranean Sea, just 93 km south of Sicily (Italy) in southern Europe. Malta is an island nation that consists of three islands: the main island Malta, Gozo and Comino. The country's official languages are Maltese and English. Malta's capital city is Valetta, which is centrally located on the island's north coast and has the island's largest harbour. The main island of Malta is the largest and most developed island. Its sister island of Gozo is idyllic and peaceful and mostly rural, offering breathtaking views and great opportunities for outdoor activities, such as hiking, biking and rock climbing. Comino is the smallest island of the three and is inhabited by only a few people.

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 can 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, eight issues [42-49] have been published and it gives me great pleasure to hereby present the ninth special issue. As with past conferences, the session chairs and co-chairs were asked to identify the best paper of each session and the 10 best papers in heat transfer were considered for this special issue. Approximately 16 other papers specifically using numerical methods were also selected for two special issues of *Computational Thermal Sciences*.

Each paper for this issue was reviewed again by a minimum of two reviewers. The current edition therefore covers the best papers of the HEFAT2012 conference held on Malta, dealing with various aspects of heat transfer engineering and its contribution, directly or indirectly, to the environment. They discuss a wide range of heat transfer engineering aspects that include the characteristics of oxyfuel and air-fuel combustion in an industrial water tube boiler, numerical and optical analysis of a weather-adaptable solar reactor, the mitigation of crystallisation fouling using projectiles in tubular heat exchangers, the mitigation of crystallisation fouling in a single heated tube using projectiles of different sizes and hardness, a framework for the analysis of thermal losses in reciprocating compressors and expanders, an annular impinging jet controlled by radial synthetic jets, multi-effect plants and ionic liquids for improved absorption chillers, the effect of climatic parameters on the heat transfer mechanisms in a solar distillation still, empirical correlations for slightly decaying grid turbulence, and pool boiling on modified surfaces using R-123.

The first article investigated the characteristics of oxyfuel combustion and air-fuel combustion in the furnace of a typical industrial water tube boiler, which used methane as fuel. Two oxyfuel cases were considered using 21% and 29% oxygen in the oxidiser mixture consisting of oxygen and carbon dioxide. The renormalised group turbulence model and the eddy dissipation model were utilised to determine the turbulence characteristics and the production rate of species. The solution of the radiative transfer equation was obtained using the discrete ordinates radiation model. The set of governing equations and boundary conditions was [if you mean: the set …was solved] solved numerically using the commercial CFD code, Fluent. A comparison of both the oxyfuel combustion and air-fuel combustion indicates that the temperature levels are reduced in oxyfuel combustion. The temperature levels were greatly reduced as the percentage of recirculated carbon dioxide is [?] increased.

A novel solar reactor with a variable aperture mechanism, which was designed and manufactured in the laboratory of the authors, was described in the second paper. A radiation heat transfer analysis of this reactor concept was studied via Monte Carlo ray tracing. The Monte Carlo ray tracing was coupled to a steady-state one-dimensional energy equation solver. The energy equation was solved for the wall and gas, accounting for the absorption, emission and convection. The incoming direct flux values for a typical day were obtained from the National Renewable Energy Lab database. Results show that for a perfectly insulated reactor, the average temperature of the working fluid may be kept appreciably constant throughout the day if the aperture diameter is varied between 3 cm and 1.5 cm.

The third paper dealt with the fouling of heat exchangers. Two spherical-type projectiles of different sizes and hardness were used to clean the inner surface of a single heated tube, which was subject to the deposition of calcium sulphate. Projectiles were introduced at different injection rates. The experimental results show firstly, that the projectiles would expedite initial nucleation of crystals even if they were soft and easy to propel inside the tube. Secondly, fouling can only be mitigated if the projectiles exert a shear force with a removal rate greater than the net rate of the deposition, thirdly, harder projectiles with larger surface contact areas were more efficient in cleaning the surface compared with those that were softer.

Flooded evaporators as compact cooling units were dealt with in the fourth paper. Flooded evaporators consist of a shell-and-tube heat exchanger, with the fluid to be cooled flowing inside the tubes of the bundle and a refrigerant that evaporates on the outside of the tubes. As pool boiling on the external surface of the tubes is a very complex process, the purpose of this paper was to determine experimentally the boiling heat transfer coefficients of R-134a and R-417A on an 18.87 mm smooth copper tube, at saturation temperatures of 7°C and 10°C. Although smooth tubes are not commonly used in shell-and-tube evaporators, it is a first approach to compare pool boiling of drop-in refrigerants.

The fifth paper reported on a framework that formally described the underlying unsteady and conjugate heat transfer processes that were undergone in thermodynamic systems, along with results from its application to the characterisation of the reciprocating compression and expansion processes in a gas spring. A model that solved the one-dimensional unsteady heat conduction equation was proposed. It was found that even at low compression ratios, notable effects of the solid walls were shown, with thermodynamic cycle losses of up to 20%. At higher compression ratios, a 19% worst-case loss was reported for common materials. These results suggest strongly that in designing high-efficiency reciprocating machines, the full conjugate and unsteady problem must be considered and that the role of the solid in determining performance cannot, in general, be ignored.

An annular impinging jet controlled by radial synthetic jets was studied experimentally in the sixth paper. An annular nozzle was designed with an active flow control system using 12 synthetic jets issuing radially from the central body of the nozzle. Measurements of the control effects were made on the impingement wall and flow visualisations were also carried out. Two main flow field patterns were identified. The patterns differ in the size of the separated flow recirculation regions that develop attached to the nozzle centre body. The control action modifies the flow field resulting in changes of the corresponding heat/mass distributions. The convective transfer rate on the stagnation circle can be demonstrably enhanced by 20% at a moderate nozzle-to-wall distance, equal to 0.6 of the nozzle diameter.

The seventh paper dealt with state-of-the-art absorption chillers using conventional working pairs that still suffer from problems like crystallisation, corrosiveness and a relatively low efficiency. To improve this technology, different working pairs as well as plant designs were investigated using *AspenPlus* as a simulation tool. The simulation was validated by comparing the results of single-effect absorption chillers using current commercially applied working pairs water/lithium bromide and ammonia/water with data in literature. Double-effect absorption chillers were implemented and analysed to increase the efficiency. The performance of two kinds of double-effect cycles, series and parallel, was compared using the working pair water/lithium bromide. In addition, ionic liquids were investigated as a sorbent in order to improve the technology. It was shown that by using ionic liquids similar or even higher COPs can be achieved in comparison with conventional working pairs. Furthermore, it was found that the main benefit of using ionic liquids as a sorbent consists in providing a broader operating range with respect to heat source temperature.

The eighth paper, was dedicated to the analysis both theoretically and experimentally of the performance of a simple solar still operating under Maltese climatic conditions. The internal and external heat transfer modes of the distillation unit were examined as well as the energy fractions within the solar still. It concluded that the distillation rate in a simple solar distiller increases with ambient temperature and solar radiation, even though the condensation capacity of the glass was reduced. A higher wind speed decreases the evaporation and condensation processes. From the energy fraction results, it was found that the glass components handle the bulk of the heat transferred in a solar still, namely radiation, evaporation and condensation and thus the distillation efficiency is enhanced by improving the thermal and optical properties of the glass.

The ninth paper considered homogeneous isotropic turbulence approximated by grid turbulence, velocity and temperature fluctuation decay under the effect of viscosity and thermal diffusivity of the fluid. In the self-similar region of grid flow, there is no mean shear and no turbulence production. The decay rate is well represented by a power law, which is supported by measurements. Relations for basic flow parameters were established as function of the normalised stream-wise distance downstream of the grid. With these relations, it was possible to determine the flow parameters for a specific passive-grid geometry or, more generally, a specific set of initial conditions.

The last paper investigated saturated pool boiling of R-123 for five horizontal copper surfaces modified by different treatments. The surfaces were an emery-polished surface, a fine sandblasted surface, a rough sandblasted surface, an electron-beam-enhanced surface and a sintered surface. The experiments were performed from the natural convection regime through nucleate boiling up to the critical heat flux, with both increasing and decreasing heat fluxes. Significant enhancement of heat transfer with increasing surface modification was demonstrated, particularly for the electron-beam-enhanced and sintered surfaces.

The conference organisers 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 and enhance the international reputation of the HEFAT conferences. The next special issue will reflect the activities of the HEFAT2014 conference, which will be held in Orlando.

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Cover

This dedicated special issue contains selected papers that were presented at HEFAT2012, held in Malta from 16 to 18 July 2012. The cover photo is from the paper by Trávniček et al. (taken up as the sixth article in this special issue) and the figure caption is ‘Flow-field patterns of the annular impinging jets: (a) A-pattern, small recirculation region (bubble), (b) B-pattern, large recirculation region. 1: annular jet, 2: nozzle centre body, 3: impingement wall, 4: central stagnation point, 5: stagnation circle, 6: reverse stagnation point, *H*: nozzle-to-wall spacing