Preface

Papers published in this special issue have been presented during the International Conference on Inverse Problems in Engineering 2014 (ICIPE2014) which took place in Kraków, Poland, in May, 2014. The ICIPE2014 was the 24th in the series of national and international meetings on inverse problems that were initiated at Michigan State University in 1988. The 2014 edition is the 8th International Conference. Both the scientific committee members and the participants come from many countries worldwide: USA, Brazil, Russia, Poland and France, among others. The primary purpose of the Conference is to provide a forum of scientist and graduate students in sciences and engineering with recent results of the inverse problems.

The topics of the Conference cover inverse problems in all branches of science and engineering including thermal sciences, structure mechanics, fluid flows, medical applications and many others. This special issue of *Numerical Methods for Heat & Fluid Flow (NMHFF)* contains, however, only papers dealing with inverse thermal problems. During the Conference, six keynote lectures have been delivered by eminent scientists. These lectures were accompanied by presentations of 96 regular papers.

The issue containing 13 contributions starts with the paper by McMasters *et al.*, entitled *Testing Extremely Small Samples Using the Flash Diffusivity Method*. The paper examines the effects of the sample holder and the contact resistance on the measured thermal diffusivity of the sample and includes experimental results of laboratory measurements. In the research, very small-sized samples of approximately 2 mm in diameter are examined. For samples of this size, the holder has to make a good contact with the entire perimeter surface of the sample, and the sample is held in place by means of friction. This requires a mathematical model for the direct solution which accommodates the holder and a contact resistance between the holder and the sample.

Second paper entitled *An Alternative Approach to Thermal Analysis using Inverse Problems in Aluminum Alloy Welding* is by C.P. da Silva. This article proposes an alternative for the thermal analysis of the TIG (tungsten inert gas) welding process on a 6060 T5 aluminium alloy. For this purpose, a C++ code was developed, based on a transient three-dimensional heat transfer model. To estimate the amount of heat delivered to the plate, the Specification Function technique was used. Laboratory experiments were carried out to validate the methodology. A new experimental methodology is proposed to estimate the emissivity radiation coefficient. The proposed methodology proved to be a cheap way to estimate the heat input to the sample. The estimated power curves for the welding process are presented. The methodology to determine the emissivity coefficient was validated.

Next paper by Bozzoli *et al.* is entitled *Estimation of the Local Heat Transfer Coefficient in Coiled Tubes: Comparison Between Tikhonov Regularization Method and Gaussian Filtering Technique*. In the paper, the applications of the solution techniques of the inverse heat conduction problem are shown. This enables estimation of the local convective heat transfer coefficient inside a pipe. In the paper, two different techniques were considered and compared: Tikhonov regularization method (TRM) and Gaussian filtering technique (GFT). They were tested considering particular problems within passive heat transfer enhancement techniques: estimating the local convective heat transfer coefficient inside coiled tubes. The comparison carried out using both

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simulating and experimental data revealed that TRM performs better than GFT if the signal is affected by low noise levels. For higher noise level values, the efficiency of both techniques is comparable.

W. Kus *et al.*, in the paper *Multicriteria Identification of Parameters in Microscale Heat Transfer*, present the multi-criteria identification method applied for solving the microscale heat transfer problem. The thin film exposed to ultrashort laser pulse is modelled using the finite difference method. The parameters of the model are tuned on the basis of experimental data. The multi-criteria identification of the numerical model parameters is performed for subsets of experimental data. The multi-criteria identification for two subsets of experimental data may lead to different results. The obtained Pareto front allows choosing the most suitable set of numerical model parameters.

The fifth work from A. Nenarokomov is entitled *Identification of Radiative Heat Transfer Parameters in Multilayer Thermal Insulation of a Spacecraft*. In the paper, the contribution to the optimization process of multilayer vacuum thermal insulation (MLI) of modern high-weight spacecrafts is presented. An adequate mathematical simulation of heat transfer in the MLI is impossible if there is no available information on the main insulation properties. The results of experiments in thermo-vacuum facilities are used to re-estimate some radiative properties of metallic foil or metalized polymer foil and spacer on the basis of the inverse problem solution. The experiments were carried out for the sample of real MLI used for BP Colombo satellite (ESA). Recently developed theoretical model based on neglecting possible near-field effects in radiative heat transfer between closely spaced aluminium foils was used in theoretical predictions of heat transfer through the MLI. Comparison of the computational results and the experimental data confirms that there are no significant near-field effects between the neighbouring MLI layers. It means that there is no considerable contradiction between the far-field model of radiative transfer in MLI and the experimental estimates.

Next paper entitled *State Estimation in Bioheat Transfer: A Comparison of Particle Filter Algorithms* was presented by Orlande *et al.* In this work, a comparison of three different algorithms of the particle filter is presented. The focus of the paper is on applications related to the hyperthermia treatment of a patient with cancer, with heating imposed either by a laser in the near-infrared range or by radiofrequency waves. The algorithms are compared in terms of computational time and solution accuracy.

Seventh paper by Z. Bulinski and H.R.B. Orlande is entitled *Estimation of the Non-linear Diffusion Coefficient with Markov Chain Monte Carlo Method based on the Integral Information*. The paper presents development of the Bayesian inverse approach for retrieving of non-linear diffusion coefficient based on the integral information. A number of formed analytical solutions of the non-linear diffusion problem were used to verify accuracy of the developed inverse approach. Reasonably good agreement, even for highly correlated parameters, was obtained. Finally, the technique was used to compute concentration-dependent diffusion coefficients of water in paper.

Next contribution is by Huayamave *et al.*, entitled *RBF-Trained POD-Accelerated CFD Analysis of Wind Loads on PV Systems*, and it proposes the application of a real-time response framework based on the proper orthogonal decomposition (POD) method for the wind-loading calculations for structures according to the American Society of Civil Engineer (ASCE) 7 standard. Such a framework uses beforehand and off-line CFD solutions from an extensive data set developed using a predefined design space. Solutions were organized to form the basic snapshots of a POD decomposition matrix. The interpolation network using radial-basis functions was used to predict the solution from the POD decomposition having given a set of values of the design variables. The results presented in this work assume varying design variables for wind speed and wind direction affecting a typical PV roof installation. The POD network was successfully validated and proved that large-scale CFD problems can be parametrized and simplified by using this framework.

The next contribution by M. Paruch is entitled *Identification of the Cancer Ablation Parameters during RF Hyperthermia using Gradient, Evolutionary and Hybrid Algorithms*. In the paper, electromagnetic field induced in 3D domain of biological tissue by two external electrodes, and the resulting temperature field in this tissue is considered. An important problem is to direct heat appropriately in the region of tumour, so as to avoid damaging healthy cells surrounding the tumour. To concentrate the heat in the tumour, some magnetic nanoparticles were recently introduced into the tumour. The nanoparticles must be made of material that ensures the appropriate magnetic properties and have high biocompatibility with biological tissue. External electric field causes appropriate heat generation in tissue domain. The aim of the investigations is to determine an electric potential of external electrodes and the number of nanoparticles introduced to a tumour region to obtain an artificial hyperthermia state. The tests performed showed that the proposed tool to solve the inverse problem provides correct results.

The tenth paper entitled *The Inverse Heat Conduction Problem Solution for a Laser Flash Study of a Thin Layer Coating* is submitted by W. Strycniewicz and J. Panas. In the paper, the inverse heat conduction methodology in a solution of a certain parameter identification problem is discussed. The problem itself concerns determination of the thermophysical properties of a thin layer coating by applying the laser flash apparatus. The modelled laser flash diffusivity data from the three-layer sample investigation are used as input for the parameter estimation procedure. The paper presents methodology developed for three-layer sample studies and results of the estimation technique testing and evaluation based on simulated data. The multi-parametrical identification procedure results in identification of the out-of-plane thin layer material diffusivity from the inverse problem solution. The presentation itself is limited to numerical simulating data, but it should be underlined that the model coating mimics the flake graphite that is frequently applied in real experiments.

Next contribution by O. Alifanov is entitled *Inverse Problems in Identification and Modeling of Thermal Processes: Russian Contributions*. The main purpose of this article is a brief overview of several approaches, developed by the author and his colleagues, to solve the ill-posed inverse heat transfer problems with their possible extension to a wider class of inverse problems of mathematical physics. Very wide possibilities of presented methodology are demonstrated discussing examples of aerospace applications.

The 12th contribution entitled *Retrieving Thermal Conductivity of the Solid Sample using Reduce Order Model Inverse Approach* was prepared by W. Adamczyk and Z. Ostrowski. Prompted by the reliability and robustness of previously developed method of non-destructive measurement of thermal conductivity (TC) for anisotropic materials, now the enhanced approach is presented. The main improvement lies in substitution of analytic solution of direct problem solver used previously with numerical one obtained using FVM. Both, a laser heat source and temperature measurements are applied on the same side of the sample material, which is the main difference with respect to classic Parker flash method. To speed up computational time, the full numerical model used in the course of an inverse solution is replaced by POD-RBF reduced order model (ROM), being fast and accurate. The measured values of thermal conductivity are in good agreement with results of well-established (but destructive) measurement methods.

The last contribution by Weglowski *et al.* is entitled *Monitoring of Thermal Stresses in Pressure Components using Inverse Heat Conduction Methods*. The purpose of the paper is to present a method for monitoring of transient thermal stresses. The paper also presents the analysis of thermal stresses of boiler pressure element heated during the start-up in real conditions. The inverse methods are used to determine the wall temperature, while the commercial software ANSYS is used to determine the thermal stresses in the pressure component. The obtained stresses and temperature in the thick wall pipe are illustrated and compared with experimental data. Satisfactory agreement was found between computational and experimental results.

We are indebted to all authors for their contributions to this special issue and for their cooperation and support. We do hope that this issue provides a window to the current interests in one branch of numerical heat transfer which is inverse thermal modelling. We would also like to thank Professor R.W. Lewis for giving us the opportunity to edit this special issue. We are also very grateful to the editorial staff of the *International Journal of Numerical Methods for Heat & Fluid Flow (IJNMHFF)* for the highly professional handling of this special issue.

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