



# Novel Numerical Methods in Heat and Mass Transfer

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**Abstract:** The Special Issue entitled “Novel Numerical Methods in Heat and Mass Transfer” focuses on such issues as CFD modeling of fluid flow, heat transfer characteristics, mass transfer, phase-change and heat exchangers. The Guest Editors of this Special Issue, under the support and auspices of the publishing house, and through its editors, invited the authors to publish their latest achievements in the area of numerical methods used in the area of heat and mass transfer. A short overview of the successful invited submission articles devoted to the above-mentioned subject is presented with the hope that these valuable works will be of interest to a wide range of readers, as the topic is important and worth further scientific attention.

**Keywords:** CFD; heat transfer; mass transfer; fluid flow; phase-change; heat exchangers

## 1. Introduction

It is hard to imagine what the current state of knowledge and the state of technology would be like if the conceptual process lacked computers and the numerical methods strongly associated with them. The use of computer methods contributed to the development of computational mechanics, and its dynamically developing branch is called computational fluid mechanics (CFD). Numerical methods allow for faster and more accurate solutions of differential equations, computer programs enabling the use of numerical methods to solve differential equations, as well as the development of areas of the scientific use of computer methods in research (computer simulation). Computer simulation, based on the mathematical model of the analyzed phenomenon, allows us to test and verify new theories and hypotheses put forward by scientists.

The Special Issue entitled “Novel Numerical Methods in Heat and Mass Transfer” focuses on such issues as CFD modeling of fluid flow, heat transfer characteristics, mass transfer, phase-change and heat exchangers. The problems of fluid mechanics are solved using analytical, experimental and computational (numerical) methods. Analytical methods allow us to solve simple cases, e.g., concerning fixed flows or geometrically uncomplicated ones—in a one- or two-dimensional space. The use of experimental methods in the study of fluid mechanics requires the construction of expensive facilities, equipped with specialized control and measurement equipment. It is often an insurmountable barrier that makes it impossible to verify the research hypotheses. The solution to these problems may be numerical fluid mechanics. In the first period of its development, it did not receive much interest as it required tedious and monotonous calculations. The situation changed with the use of computers, which replaced humans in performing time-consuming calculations. Technological progress has made it possible to use the enormous computing power installed in personal computers to solve differential equations of fluid mechanics, including the most important one, the Navier–Stokes equation. The task might seem very simple. However, the use of the Navier–Stokes equation to solve turbulent flow problems has not been fully mastered. Due to the obvious benefits of using CFDs to solve fluid mechanics problems, which are: (i) small financial outlays compared to the construction costs of experimental



**Citation:** Piasecka, M.; Dutkowski, K. Novel Numerical Methods in Heat and Mass Transfer. *Energies* **2022**, *15*, 2635. <https://doi.org/10.3390/en15072635>

Received: 24 March 2022

Accepted: 30 March 2022

Published: 4 April 2022

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facilities; (ii) the ability to simulate increasingly complex problems; (iii) almost instant availability of computer experimental data; and (iv) the ease of analysis and processing of the results, the computer methods of fluid mechanics are developing dynamically.

The Guest Editors of this Special Issue, under the support and auspices of the publishing house, and through its editors, invited the authors to publish their latest achievements in the area of numerical methods used in the area of heat and mass transfer. A short overview of the successful invited submission articles devoted to the above-mentioned subject is presented in the next section.

## 2. An Overview of the Articles Published in the Special Issue

The authors of [1] proposed a fourth-order numerical scheme to solve time-dependent partial differential equations. On the basis of the proposed diagram, the authors have solved the extended mathematical model for the mixed convection of magnetohydrodynamics (MHD) Stokes problems. It was underlined that the proposed approach is characterized by an improved region of stability rather than some explicit schemes, and it converges faster than the existing second-order Crank–Nicolson scheme. The resulting contours of the velocity and temperature profile for the Stokes second problem are presented. In their next study [2], the authors discussed the results of heat transfer in mixed convection fluid flow over a stretching sheet. In the analyzed issue, the influence of thermal radiation was additionally taken into account. The problem was solved using the model proposed by the authors. The solution obtained according to the authors' own method was compared with the solutions using the DuFort–Frankel method and the FTCS method. Time-dependent values of skin friction coefficient, Nusselt number, and local velocity values in the boundary layer for only the diffusion parabolic equation with diffusion effect (including the source term and convection-diffusion equations for several selected quantities of the dimensionless velocity component  $V$ ) were compared.

The article [3] showed the possibilities of using Trefftz functions to solve the problem of thermoelasticity in a plate. The main aim was to obtain an approximate solution for predicting the temperature, displacement and stress fields inside one- and two-layered thermoelastic media based on the coupled thermoelasticity equations. Trefftz method for solving a 1D coupled thermo-elasticity problem for one- and two-layered media was discussed. Lead Zirconate Titanate and stainless steel were assumed as the model material. The following graphical forms were shown: temperature field, displacements and stresses in one layer and composite for two layers. A comparison of temperature, displacement and stress obtained in both cases indicated much higher temperature values in the first layer, resulting from greater conductivity in the second layer, and higher values of displacements with reduced stress values. There is a significant influence of the thickness of layer 2 and its thermal conductivity coefficient on the values of temperature and displacements in layer 2 with significantly reduced stresses in this layer. Reducing the thickness of layer 2 slightly increased the temperature in layer 1, slightly reduced the displacements on the outer edge of layer 1, and slightly disturbed the stresses. In conclusion, the authors underlined the possibility of the use of Trefftz functions to solve the thermoelastic problem in a single- and double-layered medium.

The paper [4] showed the results of the CFD simulation using the COMSOL software. This software was used to simulate the convective heat exchange problem during forced water flow through the zone with the mini-channel section. The water flow was carried out simultaneously through the mini-channel section and above it. Mini-channels with a fixed length of 37.8 mm and a width of 1.615 mm had a height of 3.41 mm, 6.82 mm, 10.21 mm or 12.7 mm. Using the simulations, the local temperature of the fluid and the wall of the mini-channel were calculated. As a result, local values of the Nusselt number were determined. The simulation was carried out for five different values of the Reynolds number. The fluid flow field and the temperature distribution were also visualized in the radiator area. The most intense heat reception was found to take place at the wall of the mini-channel equal to 6.82 mm. The authors indicated that, taking into account the

frictional effects and the associated flow resistances, the 12.7 mm mini-channel appeared to be the best solution.

### 3. Conclusions

As the Guest Editors of the Special Issue entitled “Novel Numerical Methods in Heat and Mass Transfer”, and the authors of a brief review of the successful invited submission articles, we hope that these valuable works will be of interest to a wide range of readers, as the topic is important and worth further scientific attention.

**Author Contributions:** The authors made an equal contribution to the preparation of this work. All authors have read and agreed to the published version of the manuscript.

**Funding:** The research reported herein was supported by a grant from the National Science Centre, Poland, No. UMO-2018/31/B/ST8/01199.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Acknowledgments:** The authors of this editorial paper are grateful to MDPI Publishing House for the invitation to be Guest Editors of this Special Issue. The authors are also grateful to the Energies Editors for their kind cooperation, patience and commitment.

**Conflicts of Interest:** The authors declare no conflict of interest.

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