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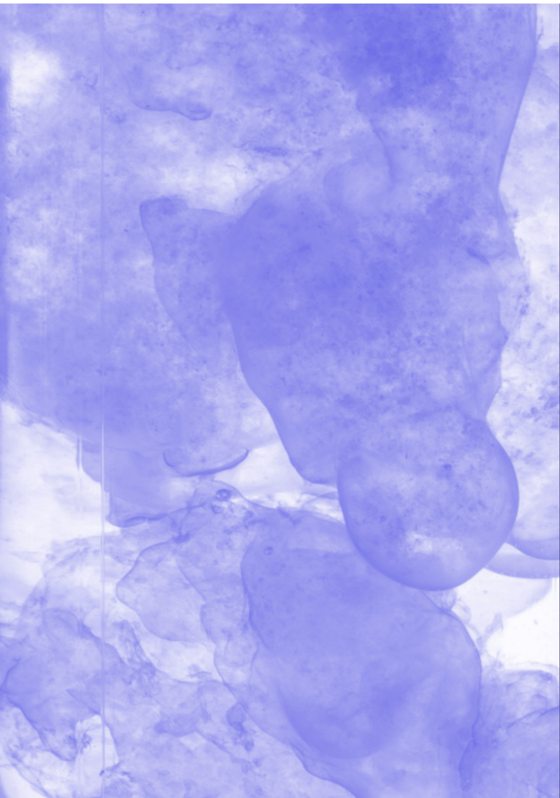

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Selected Papers

Numerical Study of Turbulent Flows over a NACA 0012 Airfoil: Insights into Its Performance and the Addition of a Slotted Flap

Authors: Brian Steenwijk and Pablo Druetta

Abstract: This work provides a comprehensive overview of various aspects of airfoil CFD simulations. The airflow around a 2D NACA 0012 airfoil at various angles of attack is simulated using the RANS SST turbulent flow model and compared to experimental data. The airfoil is then modified with a slotted flap and additionally the angle of the flap is altered. The flow model is subsequently coupled to a heat transfer model to compare the isothermal versus non-isothermal performance. The airfoil with the slotted flap shows increased *CL* and *CD* values compared to the standard NACA 0012. Larger flap angles further increase the *CL* and *CD*. The lift and drag coefficients show no difference in the non-isothermal model compared to the isothermal model, indicating the isothermal model is sufficient for this system. The 3D model without wingtips shows a similar *CL* to the 2D model as it effectively has an infinite span. Adding a wingtip reduces the lift coefficient, as the air can flow around the wingtip, increasing the pressure on top of the wing. Overall, these results match the behavior expected from wing theory well, showing how CFD can be effectively applied in the development and optimization of wings, flaps, and wingtips.

https://doi.org/10.3390/app13137890

An AMR-Based Liquid Film Simulation with Surfactant Transport Using PLIC-HF Method

Authors: Tongda Lian, Shintaro Matsushita and Takayuki Aoki

Abstract: In this study, an AMR-PLIC-HF method is proposed and implemented by GPU parallel computing based on CUDA programming language and NVIDIA GPU. The present method improves the computation efficiency without compromising the accuracy and conservation of the volume. To satisfy the requirements of stencil points of the PLIC-HF method, an extended stencil computation method based on the tree-based AMR method is proposed and implemented. The Weakly Compressible Scheme (WCS) is used in the present work as a fluid solver. An evolving pressure projection method is adopted to suppress the oscillation induced by the reflection of acoustic waves. The Langmuir model is introduced into the solver to calculate surfactant transport and the Marangoni effect caused by the gradient of the interface concentration of the surfactant. The single vortex flow results verify the accuracy of the AMR-PLIC method. A single bubble rising problem with two different physical property settings is simulated. The results show good agreement with the results given by incompressible solvers. This verifies the accuracy of the two-phase flow solver including the AMR-PLIC-HF method and the WCS. The generation and rupture of liquid film by a single bubble freely rising to an interface is simulated by the present solver with a 1024×2048 AMR grid as the finest resolution. This simulation successfully calculates surfactant transport and the Marangoni effect.

https://doi.org/10.3390/app13031955

Saturated Boiling Enhancement of Novec-7100 on Microgrooved Surfaces with Groove-Induced Anisotropic Properties

Authors: Ho-Ching Lin, Cheng-Hsin Kang, Hui-Chung Cheng, Tien-Li Chang and Ping-Hei Chen

Abstract: The effects of the anisotropic properties (wettability and roughness) of microgrooved surfaces on heat transfer were experimentally investigated during pool boiling using Novec-7100 as a working fluid. The idea for introducing the concept of anisotropic wettability in boiling experiments draws inspiration from biphilic surfaces. A femtosecond-laser texturing method was employed to create microgrooved surfaces with different groove spacings. The results indicated that anisotropic properties affected the heat transfer coefficient and critical heat flux. Relative to the plain surface, microgrooved surfaces enhanced the heat transfer performance due to the increased number of bubble nucleation sites and higher bubble detachment frequency. An analysis of bubble dynamics under different surface conditions was conducted with the assistance of high-speed images. The microgrooved surface with a groove spacing of 100 μm maximally increased the BHTC by 37% compared with that of the plain surface. Finally, the CHF results derived from experiments were compared with related empirical correlations. Good agreement was achieved between the results and the prediction correlation.

https://doi.org/10.3390/app14020495

Improvement of Blocked Long-Straight Flow Channels in Proton Exchange Membrane Fuel Cells Using CFD Modeling, Artificial Neural Network, and Genetic Algorithm

Authors: Guodong Zhang, Changjiang Wang, Shuzhan Bai, Guoxiang Li, Ke Sun and Hao Cheng

Abstract: To further improve the performance of the Proton Exchange Membrane Fuel Cell (PEMFC), in this paper, we designed a blocked flow channel with trapezoidal baffles, and geometric parameters of the baffle were optimized based on CFD simulation, Artificial Neural Network (ANN), and single-objective optimization methods. The analysis of velocity, pressure, and oxygen distribution in the cathode flow channel shows that the optimized trapezoidal baffle can improve oxygen transport during the reaction. The comparison of the optimization model with the straight flow channel model and the rectangular baffle model shows that the power density of the optimized model is 4.0% higher than that of the straight flow channel model at a voltage of 0.3 V, and the pressure drop is only 37.83% of that of the rectangular baffle model. For on-road PEMFC with a voltage of 0.6 V, the influence of pump power is significant, and the optimized trapezoidal baffle model has a net power increase of 1.47% compared to the rectangular baffle model at 50% pump efficiency and 3.94% at 30% pump efficiency.

https://doi.org/10.3390/app14010428

Comparative Study of Droplet Diameter Distribution: Insights from Experimental Imaging and Computational Fluid Dynamics Simulations

Authors: Kasimhussen Vhora, Gábor Janiga, Heike Lorenz, Andreas Seidel-Morgenstern, Maria F. Gutierrez and Maria F. Gutierrez

Abstract: The interfacial area between two phases plays a crucial role in the mass transfer rate of gas–liquid processes such as absorption. In this context, the droplet size distribution within the flow field of a droplet-based absorber significantly affects the surface area, thereby influencing the absorption efficiency. This study focuses on developing a computational fluid dynamics (CFD) model to predict the size and distribution of water droplets free-falling in a transparent square tube. This model serves as a digital twin of our experimental setup, enabling a comparative analysis of experimental and computational results. For the accurate measurement of droplet size and distribution, specialized experimental equipment was developed, and a high-speed camera along with Fiji software was used for the capturing and processing of droplet images. At the point of injection and at two different heights, the sizes and distributions of falling droplets were measured using this setup. The interaction between the liquid water droplets and the gas phase within the square tube was modeled using the Eulerian–Lagrangian (E-L) framework in the STAR-CCM+ software. The E-L multiphase CFD model yielded approximations with errors ranging from 11 to 27% for various average mean diameters, including d_{10}, d_{20}, d_{30}, and d_{32}, of the liquid droplets at two distinct heights (200 mm and 400 mm) for both nozzle plates. This comprehensive approach provides valuable insights into the dynamics of droplet-based absorption processes.

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MDPI
Grosspeteranlage 5
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