Chia-Wei Kuo, Ph.D.

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Summary

- Ph.D. in Mechanical Engineering (minored in Mathematics)
- 10+ years of experience in CFD, CAE, thermal analysis, engineering modeling, and programming
- 2 Editor's Pick Papers in *Physics of Fluids*; Phi Kappa Phi member
- 89 Google Scholar Citations; 8 Journal Publications; 16 Conference Proceedings; 1 Patent
- Served as a reviewer for 7 conference papers
- Gave over 80 presentations to industry/national sponsors as a Ph.D. student

Education

The University of Wisconsin – Madison **Madison, WI**
Ph.D. in Mechanical Engineering; minor in Mathematics November 2022
- *Research*: Developed new CFD numerical solvers for two-phase flow simulations
- *Sponsor*: Caterpillar Inc. (2016 - 2020), US Army Research Laboratory (2020 - 2022)

National Taiwan University **Taipei, Taiwan**
M.S. in Mechanical Engineering January 2016
- *Research*: Improved the heat transfer performance of an industrial motor via CAE technique
- *Sponsor*: TECO Electric and Machinery Co. (Top industrial motor manufacturer in Taiwan)

National Cheng Kung University **Tainan, Taiwan**
B.S. in Aeronautics and Astronautics June 2010
- *Project*: Design of a Hypersonic Reflective Shock Tunnel
- *Sponsor*: National Science Council of Taiwan

Full-Time Employment

Sr. Research and Development Scientist
Heraeus Quartz North America LLC, Buford, GA Nov 2022 - Present
(*One of the global leaders in optical fiber manufacturing*)
- Performing multi-physics simulations of furnaces used in Heraeus North America.

Senior Mechanical Engineer, Fan and Thermal Business Group
Delta Electronics, Taiwan Feb 2016 - Apr 2016
(*Top industrial and computer fan manufacturer in Taiwan*)
- Assisted the noise measurement of Delta's ventilation fan products.
- Designed the accessory kit packages of Delta's GBR, SMT, and SLM-series ventilation fans.

Assistant Researcher, Solar Thermal Research Team
NCKU Research and Development Foundation, Taiwan Aug 2011 - Dec 2013
(*Leading renewable energy program sponsored by Taiwan Bureau of Energy*)
- Improved the heat transfer performance of an industrial oven, making the temperature variation inside the oven less than $7K$.
- Analyzed the thermal efficiency of large-scale solar thermal systems.
- Propose the 1^{st} model for estimating the solar thermal diffuse fractions in Taiwan.

Honor

- 2 Editor Pick's Papers in the preeminent fluid dynamics journal *Physics of Fluids* 2022
- Phi Kappa Phi Member (Top 10% Graduate in University of Wisconsin - Madison) 2018
- Phi Tau Phi Member (Top 1% Undergraduate in National Cheng Kung University) 2010
- National Science Council Undergraduate Research Scholarship 2009

Technical Skills

CFD: OpenFOAM, Fluent, COMSOL, CFX, ICEMCFD, Pointwise
Programming: C++, C, FORTRAN, MATLAB
CAD: AutoCAD, SolidWorks, Pro/E, ANSYS Workbench
Renewable Energy Engineering: TRNSYS

DOCTORAL RESEARCH

Developed New CFD Solvers for High Fidelity Simulations of Engine Sprays

- Developed novel C++ CFD numerical solvers for performing high-fidelity simulations of engine sprays with much lower computational cost. The new solver is projected to save around 20 times of CPU-hrs compared with traditional approaches.
- The new features of this solver include the followings:
  1. implemented within the open-source C++ platform, `OpenFOAM`.
  2. included compressible pressure Poisson and energy equation solvers for addressing fluid compressibility and heat transfer phenomena.
  3. included droplet breakup models to describe the secondary atomization of sprays.
  4. included Lagrangian vaporization models to compute droplet vaporization.
  5. employed Crank-Nicolson scheme to numerically solve the droplet equation of motion.
  6. can be successfully applied in large-scale engineering parallel computations.

Modeling of Secondary Droplet Breakup in Sprays

- Developed one of 1^{st} droplet breakup models based on Maximum Entropy Formalism (MEF) to compute further hydrodynamic breakup of droplets in sprays. The model satisfies the conservation constraint of mass, momentum, and energy.
- Fewer empirical correlations are required to reach a full closure of the model.
- The model shows that droplet size and velocity are dependently distributed, which contrasts with the assumptions commonly adopted in the literature.

Analyzed the Speedup Performance of Adaptive Mesh Refinement (AMR) Method for Spray Problems

- Proposed the 1^{st} analytical expression for estimating the upper-bound of AMR speedup performance.
- The analysis shows that using AMR cannot totally alleviate the computational cost of spay simulations. Besides the load balancing issue, a less obvious contributor to diminishing AMR performance is the increasing Frobenius condition number of AMR, which is associated with the eigenvalues of the pressure Poisson matrix.

MASTER RESEARCH

Heat Dissipation Enhancement of an Industrial Totally-Enclosed Fan-Cooled Motor through Frame Designs

- Enhanced the heat dissipation performance of a large-scale industrial motor, making the maximum temperature below $403K$ and the average temperature difference below $10K$.
- Proposed 8 new designs of fins that are mounted on the industrial motor frame.

PART-TIME EMPLOYMENT

Graduate Research Assistant, Department of Mechanical Engineering
The University of Wisconsin – Madison Aug 2016 - Nov 2022

- Developed C++ numerical solver titled VoFLE for large-scale spray simulations

Graduate Teaching Assistant, Department of Mechanical Engineering
The University of Wisconsin – Madison Jan 2021 - Dec 2021

- Graded the graduate-level courses *Computational Fluid Dynamics* and *Intermediate Fluid Dynamics*

Graduate Research Assistant, Department Mechanical Engineering
National Taiwan University, Taiwan Aug 2014 - Jan 2016

- Improved the heat transfer rate of an industrial motor via CFD and CAE techniques.

Undergraduate Researcher, Department of Aeronautics and Astronautics
National Cheng Kung University Feb 2009 - Jan 2010

- Assisted in drawing 40 sheets of engineering blueprints on a hypersonic reflective shock tunnel.

CERTIFICATIONS

Machine Learning

- **C.W. Kuo**. "Introduction to TensorFlow for artificial intelligence, machine learning, and deep learning." *DeepLearning.AI*, 2021.

PROFESSIONAL AFFILIATIONS

Society of Automotive Engineers (SAE) International 2016 - Present

REVIEWERS

2021 SAE International Conference on Engines & Vehicles: 2 papers reviewed	2021
2021 ASME Internal Combustion Engine Fall Conferences: 2 papers reviewed	2021
2020 ASME Internal Combustion Engine Fall Conferences: 1 paper reviewed	2020
2019 Thermal and Fluids Engineering Conference: 1 paper reviewed	2019
2017 SAE International Conference on Engines & Vehicles: 1 paper reviewed	2017
Applied Energy Journal (IF: 9.746 as of 2022): invited review for 1 paper	2016

PATENTS

Heat Transfer

- M.Y. Hsu, C.H. Wang, C.H. Tsai, M.J. Huang and **C.W. Kuo**. "Motor frame with splitting type heat dissipation channel." *Taiwan Intellectual Property Office*, TWM537180, 2017.

PUBLICATIONS

Journal Publications

1. **C.W. Kuo** and M.F. Trujillo. "Simulation of liquid jet atomization and droplet breakup via a Volume-of-Fluid Lagrangian-Eulerian strategy." *Physics of Fluids*, 34, 113326, 2022 (selected as an Editor's Pick Paper).
2. **C.W. Kuo** and M.F. Trujillo. "A maximum entropy formalism model for the breakup of a droplet." *Physics of Fluids*, 34, 013315, 2022 (selected as an Editor's Pick Paper).
3. **C.W. Kuo** and M.F. Trujillo. "An analysis of the performance enhancement with adaptive mesh refinement for spray problems." *International Journal of Multiphase Flow*, 140: 103615, 2021.
4. C.W. Tseng, **C.W. Kuo**, M.F. Trujillo and C. Rutland. "Evaluation and validation of large-eddy simulation sub-grid spray dispersion models using high-fidelity volume-of-fluid simulation data and engine combustion network experimental data." *International Journal of Engine Research*, 20(6): 583-605, 2019.
5. **C.W. Kuo** and K.C. Chang. "In-situ measurements of solar diffuse fraction in southern Taiwan." *Journal of the Chinese Institute of Engineers*, 38(6): 723-730, 2015.
6. **C.W. Kuo**, W.C. Chang and K.C. Chang. "Modeling the hourly solar diffuse fraction in Taiwan." *Renewable Energy*, 66: 56-61, 2014.
7. **C.W. Kuo**, P.S. Yen, W.C. Chang and K.C. Chang. "The design and optical analysis of compound parabolic collector." *Procedia Engineering*, 79: 258-262, 2014.
8. **C.W. Kuo**, W.C. Chang and K.C. Chang. "Distribution of solar diffuse fraction in Taiwan." *Energy Procedia*, 57: 1120-1129, 2014.

Conference Proceedings

1. M.F. Trujillo and **C.W. Kuo**. "Modeling spray atomization by a hybrid Volume-of-Fluid Lagrangian-Eulerian approach." *75th Annual Meeting of the Division of Fluid Dynamics, Bulletin of the American Physical Society*, Indianapolis, IN, 2022.
2. **C.W. Kuo**, M. Ananth, A. Strzelec and M.F. Trujillo. "VoFLE simulations to model UWS spray evaporation." *The ASME ICE Forward 2022 Conference*, Indianapolis, IN, 2022.
3. **C.W. Kuo** and M.F. Trujillo. "Volume-of-Fluid Lagrangian-Eulerian model for spray simulations." *ILASS-Americas* 32^{th} *Annual Conference on Liquid Atomization and Spray Systems*, Madison, WI, 2022.
4. **C.W. Kuo** and M.F. Trujillo. "Statistical model of splashing products from the breakup of a droplet." *ILASS-Americas* 31^{th} *Annual Conference on Liquid Atomization and Spray Systems*, 2021 (virtual).

5. **C.W. Kuo** and M.F. Trujillo. "Examining the deterioration of adaptive mesh refinement performance in spray computations." *ILASS-Americas* 31^{th} *Annual Conference on Liquid Atomization and Spray Systems*, 2021 (virtual).
6. **C.W. Kuo** and M.F. Trujillo. "Revisiting the Promise of Adaptive Mesh Refinement." *ILASS-Americas* 30^{th} *Annual Conference on Liquid Atomization and Spray Systems*, 2020 (virtual).
7. **C.W. Kuo** and M.F. Trujillo. "A Maximum-Entropy-Formalism for Secondary Droplet Breakup." *ILASS-Americas* 30^{th} *Annual Conference on Liquid Atomization and Spray Systems*, 2020 (virtual).
8. **C.W. Kuo** and M.F. Trujillo. "Speedup analysis of adaptive mesh refinement in the simulation of spray formation." *ILASS-Americas* 30^{th} *Annual Conference on Liquid Atomization and Spray Systems*, Tempe, AZ, 2019.
9. **C.W. Kuo** and M.F. Trujillo. "A study of adaptive mesh refinement speedup in spray atomization." *International Multidimensional Engine Modeling Usersˊ Group Meeting at the SAE Congress*, Detroit, MI, 2019.
10. **C.W. Kuo** and M.F. Trujillo. "Benefits of AMR for atomization calculations." *ICLASS 2018,* 14^{th} *Triennial International Conference on Liquid Atomization and Spray Systems*, Chicago, IL, 2018.
11. **C.W. Kuo** and M.J. Huang. "Fin designs of TEFC motor: heat dissipation enhancement." *The* 22^{th} *National Computational Fluid Dynamics Conference*, New Taipei, Taiwan, 2015.
12. P.S. Yen and **C.W. Kuo**. "Policy for solar water heaters in Taiwan: An International Perspective," *Grand Renewable Energy*, Tokyo, Japan, 2014.
13. **C.W. Kuo**, P.S. Yen and K.C. Chang. "Generation of typical solar radiation 2014 year for Taiwan." *Grand Renewable Energy*, Tokyo, Japan, 2014.
14. **C.W. Kuo**, K.C. Chang and P.W. Chen. "In situ analysis of solar diffuse fraction in Tainan," *The* 30^{th} *Conference of the Chinese Society of Mechanical Engineers*, Yilan, Taiwan, 2013.
15. **C.W. Kuo**, Y.C. Liu and W.C. Chang. "Modeling of heat transfer in an industrial electric oven." *The* 20^{th} *National Computational Fluid Dynamics Conference*, Nantou, Taiwan, 2013.
16. **C.W. Kuo**, I.M. Liu and T.S. Li. "Optimization of large-scale solar thermal systems: A case study," *The* 19^{th} *National Computational Fluid Dynamics Conference*, Penghu, Taiwan, 2012.

Workshop/Symposium

1. M.F. Trujillo **C.W. Kuo**. "Simulation of liquid jet atomization and droplet breakup via a Volume-of-Fluid Lagrangian-Eulerian strategy." *Center for Unmanned Aircraft System Propulsion (CUP) 4th CUP Workshop*, 2022 (virtual).
2. **C.W. Kuo** and M.F. Trujillo. "Developing Volume-of-Fluid Lagrangian-Eulerian model for spray simulations." *Annual Meeting of Direct-injection Engine Research Consortium, The University of Wisconsin - Madison*, Madison, WI, 2022.
3. **C.W. Kuo** and M.F. Trujillo. "Analyzing the benefits of adaptive mesh refinement in highly-resolved VoF simulations of atomization." *Annual Meeting of Direct-injection Engine Research Consortium, The University of Wisconsin - Madison*, Madison, WI, 2019.

Thesis

1. **C.W. Kuo**. "Volume-of-Fluid Lagrangian-Eulerian models for spray simulations." *Ph.D. dissertation*, The University of Wisconsin - Madison, 2022.
2. **C.W. Kuo**. "Heat dissipation enhancement of an industrial totally-enclosed-fan-cooled motor through frame designs." *M.S. thesis*, National Taiwan University, Taiwan, 2016.
3. **C.W. Kuo**. "Design of a hypersonic reflective shock tunnel." *Undergraduate Special Project*, National Cheng Kung University, Taiwan, 2010.

Graduate Coursework

Mechanical Engineering

- (*Fluid Dynamics*) Ideal Fluid Flows, Turbulent Flows, Viscous Flows, Compressible Flows, Intermediate Fluid Dynamics
- (*Thermal Dynamics/Heat Transfer*) Intermediate Thermodynamics, Advanced Thermodynamics, Heat Transfer, Heat Conduction and Radiation, Turbo Engine Principle
- (*Numerical Method*) Computational Fluid Dynamics, High Performance Scientific Computing

Mathematics

- Methods of Computational Mathematics, Methods of Applied Mathematics, Numerical Linear Algebra

Graduate Course Projects

Green's Function Solutions for 2D Non-Homogenous Diffusion Equations
Course: Methods of Applied Mathematics (I) Nov 2018 - Dec 2018

- Derived analytical solutions to linear advection-diffusion problems using the Green's function.
- Applied this approach to identify flow structures in engineering sprays.

Parallelizing a Two-Phase Advection Equation Solver Using OpenMP, MPI and CUDA
Course: High Performance Scientific Computing Nov 2017 - Dec 2017

- Implemented multi-core, multi-node and GPU parallelizations of a two-phase advection solver.
- Demonstrated a speedup of 47.5X on GPUs and 22.4X on CPUs.

Volunteering

Asian Mental and Health Association Feb 2014 - May 2014
Assistant