ZACHARY GRANT MILLS

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EDUCATION

Georgia Institute of Technology, Atlanta, GA

Ph.D. in Mechanical Engineering, GPA: 3.85/4.00 May 2017

Research Advisor: Dr. Alexander Alexeev

Thesis: "Transport Processes in Wavy Walled Channels"

B.S. with high honors in Mechanical Engineering, GPA: 3.35/4.00 May 2011

RESEARCH EXPERIENCE

Staff Scientist March 2020-Present

Oak Ridge National Laboratory, Manufacturing Science Division, Oak Ridge, TN

- Using computational methods, specifically the finite volume (FVM) and discrete element methods (DEM) to investigate and improve fluidized bed chemical vapor deposition (FBCVD) coaters used to produce tri-structural isotropic (TRISO) nuclear fuel particles.
- Employing numerical techniques to simulate flow and heat/mass transfer in chemical vapor infiltration (CVI) reactors. Results from these simulations will inform the design of future CVI reactors capable of producing advanced high temperature ceramics for use in the aviation and energy production industries.
- Utilizing both low and high-fidelity computational models to examine possible efficiency improvements in both light-duty DISI gasoline and heavy-duty CI diesel engines enabled by new high-temperature iron and aluminum alloys developed at ORNL. Engines constructed from these alloys will be capable of achieving greater temperatures than those currently in use, reducing thermodynamic losses associated with cooling.

Postdoctoral Researcher October 2018-Present

Oak Ridge National Laboratory, Energy and Transportation Science Division, Oak Ridge, TN

Research Advisor: Dr. Charles Finney

- Used computational methods, specifically Eulerian-Eulerian (two-fluid models) and Eulerian-Lagrangian (PIC and DEM) to investigate and improve fluidized bed reactors used in biomass pyrolysis and upgrading of bio-oils.
- Collaborated with researchers at the National Renewable Energy Laboratory (NREL) and National Energy Technology Laboratory (NETL) to develop and validate new kinetic models for catalytic upgrading of bio-oils. Recently validated a reactor agnostic lumped kinetic model for catalytic upgrading of bio-oil over ZSM-5 that significantly out-performed existing models.

Postdoctoral Researcher May 2017-October 2018

Oak Ridge National Laboratory, Material Science and Technology Division, Oak Ridge, TN

Research Advisor: Dr. Michael Lance

- Investigated the influence of engine operating conditions on fouling in exhaust gas recirculation (EGR) coolers by comparing the spatially varying thickness and properties of fouling layers formed in twenty identical coolers fouled under experimental conditions.
- Developed GPU accelerated computational model for simulating fouling in EGR coolers, which was used to examine the performance of novel EGR cooler geometries.

Research Assistant/Ph.D. Candidate August 2011-December 2016

Georgia Institute of Technology, Department of Mechanical Engineering, Atlanta, GA

Research Advisor: Dr. Alexander Alexeev

- Investigated fluid flow and heat transfer enhancement in complex wavy walled geometries using purpose build based computational model based on the lattice Boltzmann method (LBM).
- Developed advanced GPU accelerated computational model to simulate the formation of a fouling layer in exhaust gas recirculation (EGR) heat exchangers.

- Studied the use of rotating magnetic microbeads in microfluidic devices to perform rapid on-site testing of food products for bacteria contamination.
- Researched use of passive and active microscale surface structures to enhance heat and mass transport in microfluidic devices.
- Trained and supervised six undergraduate research students each of whom assisted on single project over the span of one or more semesters.

Undergraduate Research Assistant October 2009-May 2011
Georgia Institute of Technology, Department of Mechanical Engineering, Atlanta, GA
Research Advisor: Dr. David Hu

GRANT AWARDS

Lab Directed Research & Development Seed Award, Oak Ridge National Lab August 2022
Project Title: *In-situ heat control strategies for fast exothermic catalytic reactors: Catalytic material design informed by the numerical-modeling*

Lab Directed Research & Development Seed Award, Oak Ridge National Lab February 2021
Project Title: *Transforming the coated nuclear fuels fabrication process*
Additional Award: HPC time allocation on Sawtooth Supercomputer at Idaho National Lab
Source: Rapid Turnaround Experiment Award, DOE Nuclear Science User Facilities (NSUF)

HPC4EnergyInnovation (HPC4EI), Department of Energy (EERE) September 2020
Project Title: *Data-driven Kinetics Modeling of Chemical Vapor Infiltration for Ceramic Matrix Composites Manufacturing*
Additional Award: HPC time allocation on Eagle Supercomputer at National Renewable Energy Lab
Source: Department of Energy (EERE)

PUBLICATIONS

Peer Reviewed Articles:

- O.A. Oyedeji, M.B. Pecha, C.E.A. Finney, C.A. Peterson, R.G. Smith, **Z.G. Mills**, X. Gao, M. Shahnam, W.A. Rogers, P.N. Ciesielski, R.C. Brown, J.E. Parks II (2022). *CFD–DEM modeling of autothermal pyrolysis of corn stover with a coupled particle-and reactor-scale framework*. Chemical Engineering Journal: 136920.
- **Z.G. Mills**, C.E.A. Finney, J.A. Haynes, A. Trofimov, H. Wang, D.T. Pierce (2021). *Impact of Materials Properties on Higher-Temperature Engine Operation*. SAE International Journal of Advances and Current Practices in Mobility 2(4).
- B.D. Adkins, **Z.G. Mills**, J.E. Parks II, M.B. Pecha, P.N. Ciesielski, K. Iisa, C. Mukarakate, D.J. Robichaud, K. Smith, K. Gaston, M.B. Griffin, J.A. Schaidle (2021). *Predicting thermal excursions during in situ oxidative regeneration of packed bed catalytic fast pyrolysis catalyst.* Reaction Chemistry & Engineering 6(5): 888-904.
- M.J. Lance, **Z.G. Mills**, J.C. Seylar, J.M.E. Storey, C.S. Sluder (2018). *The effect of engine operating conditions on exhaust gas recirculation cooler fouling.* International Journal of Heat and Mass Transfer 126: 509-520.
- **Z.G. Mills**, A. Warey, A. Alexeev (2016). *Heat transfer enhancement and thermal–hydraulic performance in laminar flows through asymmetric wavy walled channels.* International Journal of Heat and Mass Transfer 97: 450-460.
- M. Ballard, D. Owen, **Z.G. Mills**, P.J. Hesketh, A. Alexeev (2016). *Orbiting magnetic microbeads enable rapid microfluidic mixing.* Microfluidics and Nanofluidics 20(6): 1-13.
- **Z.G. Mills**, T. Shah, A. Warey, S. Balestrino, A. Alexeev (2014). *Onset of unsteady flow in wavy walled channels at low Reynolds number*. Physics of Fluids 26(8): 084104.

- M. Ballard, **Z.G. Mills**, S. Beckworth, A. Alexeev (2014). *Enhancing nanoparticle deposition using actuated synthetic cilia.* Microfluidics and nanofluidics 17(2): 317-324.
- **Z.G. Mills**, W.B. Mao, A. Alexeev (2013). *Mesoscale modeling: solving complex flows in biology and biotechnology.* Trends in Biotechnology 31(7): 426-434.
- **Z.G. Mills**, B. Aziz, A. Alexeev (2012). *Beating synthetic cilia enhance heat transport in microfluidic channels.* Soft Matter 8(45): 11508-11513.
- A.K. Dickerson, **Z.G. Mills**, D.L. Hu (2012). *Wet mammals shake at tuned frequencies to dry.* Journal of the Royal Society Interface 9(77): 3208-3218.

Articles in Review:

- **Z.G. Mills**, V. Bharadwaj, X. Gao, B. Pecha, G. Wiggins, P. Ciesielski, C.E.A. Finney, J. Parks, *Development and Validation of a Lumped Kinetic Model for Catalytic Fast Pyrolysis Upgrading Over a ZSM-5 Catalyst.*
- **Z.G. Mills**, G. Wiggins, X. Gao, L. Liu, C.E.A. Finney, *Effect of light gas addition on biomass pyrolysis in bubbling fluidized beds.*

Conference Papers:

- **Z.G. Mills**, C.E.A. Finney, K.D. Edwards, J.A. Haynes (2019). *Benefits of higher-temperature operation in boosted SI engines enabled by advanced materials.* ASME 2018 Internal Combustion Engine Fall Technical Conference, American Society of Mechanical Engineers: ICEF2018-9739
- **Z.G. Mills**, B. Aziz, A. Alexeev (2012). *Designing Active Surface Structures to Regulate Heat Transport in Microchannels*. ASME 2012 Conference on Smart Materials, Adaptive Structures and Intelligent Systems, American Society of Mechanical Engineers.

CONFERENCE PRESENTATIONS/POSTERS

- 2020 SAE Powertrains, Fuels & Lubricants Conference, *Impact of Materials Properties on Higher-Temperature Engine Operation.*
- 2019 AIChE Annual Meeting, *Effect of light gas addition on biomass pyrolysis in bubbling fluidized beds.*
- 2019 NETL Multiphase Flow Science Workshop, *Influence of Operating Parameters on Mixing and Elutriation in Fluidized Bed Pyrolysis Reactors.*
- 71st Annual Meeting of the APS Division of Fluid Dynamics, *The effect of complex geometries on exhaust gas recirculation cooler fouling.*
- ASME 2018 Internal Combustion Engine Fall Technical Conference, *Benefits of higher-temperature operation in boosted SI engines enabled by advanced materials.*
- 68th Annual Meeting of the APS Division of Fluid Dynamics, *Bifurcations in flow through a wavy walled channel*, Boston, MA, November, 2015.
- American Institute of Chemical Engineers Annual Meeting, *Reducing thermophoretic deposition in heat exchangers using wavy walled channels*, Atlanta, GA, November, 2014.
- 67th Annual Meeting of the APS Division of Fluid Dynamics, *Onset of unsteady flow in wavy walled channels at low Reynolds numbers*, San Francisco, CA, November, 2014.
- 67th Annual Meeting of the APS Division of Fluid Dynamics, *Using falling soap film to visualize flow in a wavy channel*, San Francisco, CA, November, 2014.

- 66th Annual Meeting of the APS Division of Fluid Dynamics, *Flow characteristics and heat transfer in wavy walled channels.* Pittsburgh, PA, November, 2013.
- 5th International Symposium on Bifurcations and Instabilities in Fluid Dynamics, *Flow instability in pressure-driven flow through wavy channels*, Haifa, Israel, July 2013.
- 65th Annual Meeting of the APS Division of Fluid Dynamics, *Using chiral structures to enhance particle deposition in microfluidic devices,* San Diego, CA, November, 2012.
- 65th Annual Meeting of the APS Division of Fluid Dynamics, *Modeling thermophoretic deposition of particles from a hot fluid stream,* San Diego, CA, November, 2012.
- ASME Conference on Smart Materials, Adaptive Structures, and Intelligent Systems, *Designing active surface structures to regulate heat transport in microchannels*, Stone Mountain, GA, September, 2012
- American Physical Society March Meeting, *Using actuated synthetic cilia to enhance microscale heat transport,* Boston, MA, March, 2012.

INVITED SEMINARS

- Oak Ridge National Laboratory, *Transforming the coated nuclear fuels fabrication process*, Oak Ridge, TN, February, 2021
- Oak Ridge National Laboratory, *Using computational fluid dynamics and heat transfer to enhance engineering research and development,* Oak Ridge, TN, February, 2020.
- Oak Ridge National Laboratory, *Transport processes in wavy walled channels,* Oak Ridge, TN, June, 2017.
- General Motors Research and Development, *Modeling of fouling in exhaust gas recirculation (EGR) heat exchangers,* Warren, MI, July 31, 2012

TEACHING EXPERIENCE

Lab Development Assistant May 2016-December 2016

Georgia Institute of Technology, Department of Mechanical Engineering, Atlanta, GA

- Assisted undergraduate lab coordinator with construction and maintenance of lab equipment used in undergraduate labs
- Developed new experiment and designed and built equipment for students to learn about acoustical instrumentation and analysis in undergraduate "Experimental Methods" course

Teaching Assistant January 2014-April 2016

Georgia Institute of Technology, Department of Mechanical Engineering, Atlanta, GA

- Presented labs lectures, supervised labs and graded reports for *Experimental Methods* and *Numerical Methods* courses.

SKILLS

- **Programming Languages:** C/C++ [advanced], OpenCL [advanced], Python [advanced], Matlab [advanced], Fortran [intermediate], CUDA [intermediate], Java [intermediate]
- **HPC Libraries:** MPI, Kokkos, Trillinos, PETSc, SYCL, OpenACC, OpenMP
- **CFD Software:** Ansys Fluent, COMSOL, OpenFOAM, Multiphase Flow with Interface Exchanges (MFiX), CONVERGE, widely applicable Lattice Boltzmann from Erlangen (waLBerla)

AWARDS

Undergraduate Research Featured in Sen. Jeff Flake's *Twenty Questions: Government Studies That Will Leave You Scratching Your Head*. May 2016

Project: *How many shakes does it take for a wet dog to dry off?*

- Response from my research advisor, Dr. David Hu, who led 3 of the 20 projects profiled in report can be found at https://blogs.scientificamerican.com/guest-blog/confessions-of-a-wasteful-scientist/
- Response from the National Science Foundation which funded many of the projects can be found at https://www.nsf.gov/about/congress/reports/responsetosenflakestwentyquestions.pdf

First Place Student Poster Award November 2012

APS Division of Fluid Dynamics 2012 Student Poster Design Competition

- Category: Turbulence/Energy/Geophysics
- Poster Title: "Modeling thermophoretic deposition from a hot fluid stream"

First Place Award April 2011

George W. Woodruff School of Mechanical Engineering Capstone Design Expo

- Project Sponsor: Caterpillar Inc.
- Project Title: "An OSHA compliant, rapid deploying entryway for use in diesel power modules"

President's Undergraduate Research Award May 2010

Georgia Institute of Technology

- Awarded to study fluid mechanics of water removal in mammals with Dr. David Hu

LEADERSHIP POSITIONS/ACTIVITIES

Volunteer/Technical Support July 2022-Present

East Tennessee Environmental Educators (ETEE), Knoxville, TN

- Assisting with website development and technical support
- Helping with setup of ETEE water quality education events around East TN.

Social Chair/Webmaster October 2017-September 2019

Oak Ridge Postdoctoral Association (ORPA), Oak Ridge, TN

- Developed and maintained internal ORNL website for the postdoc association
- Planned and organized social events for all postgraduates employed at ORNL
- Assisted with planning and organizing the 2018 Annual ORPA Symposium

Board Member/Literature & Supplies Chairperson May 2012-February 2015

Freedom Club Inc., Marietta, GA

- Assisted with operations of the non-profit which provides a place for local support groups to meet
- Purchased relevant literature, and maintained stock of supplies necessary for organization to function

Board Member/Treasurer August 2011-February 2015

Lost and Found, Marietta, GA

- Assisted with the operation of bi-weekly support group meetings operated by this non-profit
- Maintained finances of organization

Volunteer June 2009-August 2011

Ridgeview Institute, Smyrna, GA

- Served as a mentor to young adults enrolled in program
- Continued mentoring several individuals after their completion of the program
- Provided transportation for enrollees to attend local support group meeting

Board Member/Hospitals and Institutions Chairperson June 2009-August 2011

Northside Young People, Atlanta, GA

- Assisted with the operation of a weekly support group meeting operated by this non-profit
- Served as liaison between this organization and local hospitals and institutions