ARPAN SIRCAR

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POSITIONS

R&D Associate: CFD Applications Engineer, Thermal Hydraulics group *January 2023 – Present*

UT-Battelle at Oak Ridge National Laboratory, *Oak Ridge, TN*

- Using Direct Numerical Simulation (DNS) with Nek5000 to develop a database for turbulent MHD flows relevant to fusion reactor blanket conditions.
- Modeling magnetohydrodynamic (MHD) turbulence effects in thermal hydraulics of tokamak devices. Implementing new MHD turbulence models for liquid metals and molten salts in open-source software.
- Towards exascale multiphysics simulations of fusion reactor blankets.
- Techno-economic analysis of integrated Direct Air Capture systems for decarbonization of Nuclear Power Plants.
- Pursuing research in CFD applications of decarbonization, fuel cells, ICEs, and biological systems.
- Machine Learning for model order reduction of DNS data.

POSTDOCTORAL EXPERIENCE

Postdoctoral Research Associate, Thermal Hydraulics group *January 2021 – December 2022*

UT-Battelle at Oak Ridge National Laboratory, *Oak Ridge, TN*

- Simulating turbulent heat transfer by Molten Salts (such as FLiBe) and liquid metals (such as Lead-Lithium) to transfer energy deposited by neutron transfer in fusion reactor blankets. Use detailed CFD simulations to analyse blanket effectiveness and identify hot spots for potential design improvements.
- Coupling multiple solvers to perform multiphysics (plasma physics, neutronics, thermal hydraulics of MHD turbulent flows, and structural mechanics) simulations of innovative fusion reactor concepts.
- Optimization of fusion blanket designs using reduced order models for coupled neutronics-thermal-hydraulics, conjugate heat transfer, fluid structure interaction and conjugate electromagnetics.
- Modeling propane combustion using Level Set methods for tracking flame propagation in long-stroke Spark Ignition engines to attain diesel-like efficiencies.
- Testing wall heat transfer models to capture flame-wall interactions in internal combustion engines.
- Developing Lattice-Boltzmann methods and porting open-source CFD solvers like OpenFOAM to massively parallel architecture including GPUs.
- Pursuing research opportunities for CFD modeling of two-phase flow and heat transfer using Volume of Fluid approaches in fuel cells and electrolyzers in collaboration with companies for the HPC4EI program, and discrete element modeling (DEM) of catalyst inks for Seed proposals.

Postdoctoral Research Associate, Nuclear Eng. *February 2020 – December 2020*

Texas A&M University, *College Station, TX*

- Investigating coupled conjugate heat transfer and wall modelled LES techniques to simulate gas turbine flows for the Naval Air Warfare Center Aircraft Division, jointly with Advanced Cooling Technologies.
- Performing LES of compressible non-isothermal flow past a heated circular cylinder at different Reynolds numbers; supervised by Prof. Mark Kimber. Showed that turbulent heat fluxes in the wake, scale directly with the conductive wall heat flux at the cylinder for a range of cylinder temperatures.
- Predicting laminarization and recovery of buoyancy aided flows for a range of Richardson numbers. Demonstrated the early laminarization in Lead-Bismuth Eutectics due to heat transfer.

- Using Proper Orthogonal Decomposition (POD) analyses to formulate Reduced Order Models for turbulent heat flux and wall heat transfer in turbulent non-isothermal flows past bluff bodies.

EDUCATION & RESEARCH

PhD, Mechanical Eng. (minor Computational Science), GPA 3.94/4.0 *August 2013 – January 2020*
The Pennsylvania State University, *University Park, PA*

- Dissertation: "Computational fluid dynamics (CFD) modeling of turbulence, radiation and their interactions in internal combustion engines (ICE)", advised by Prof. Daniel C. Haworth. All undertaken projects during PhD were funded by the Department of Energy and the National Science Foundation.
- Developed hybrid (mixed URANS/LES) two-zone (1D/3D) turbulent flow solver using OpenFOAM to capture non-equilibrium effects (pressure-gradients, variable properties and low Reynolds-number) in boundary layers of channel flows and simple research engines as a step towards predictive models.
- Incorporated a turbulent-Prandtl-number based heat transfer model which accounts for turbulence-radiation interactions (TRI) in boundary layers of modern-day engines which can predict modified log-law, leading to rectified wall heat loss and engine efficiency predictions.
- Analysed TRI effects to demonstrate the role of radiation in knocking of the TCC (Transparent Combustion Chamber) engine with a simple flame propagation model.
- Coupled turbulent-combustion PDF models with the PMC radiation solver to obtain spectral distribution of radiative emission and absorption of participating gases, soot and cylinder walls in TCC.
- Incorporated robust wall heat transfer models for engine combustion simulations which reduced ~100% over-predictions of existing models to within experimental uncertainty in a Volvo 13L engine.
- Developed radiative transport equation (RTE) solvers (P1, fvDOM, Photon Monte Carlo (PMC)), jointly with Prof. Michael F. Modest's group at U.C. Merced, to show that gas-phase radiation not only dominates soot radiation by ~50% but also impacts NOx and soot formation in the same Volvo engine.

Master of Tech., Thermal & Fluid Sc., Mechanical Eng., GPA 9.8/10.0 *August 2011 – July 2013*
Indian Institute of Technology (IIT) Bombay, *Mumbai, India*

- Dissertation: "Turbulence modeling of supercritical flows", advised by Prof. Kannan N. Iyer.
- Developed buoyancy-driven turbulence models explaining heat transfer regimes in supercritical flows of Generation IV nuclear reactors (40-50% more efficient than light water reactors, LWRs).
- Modelled large property variations in critical and pseudocritical phases of water to help understand the heat transfer behaviour in reactors at the Bhabha Atomic Research Center (BARC), Bombay.

Bachelor of Tech., Mechanical Eng., GPA 9.0/10.0 *July 2007 – May 2011*
Jadavpur University, *Kolkata, India*

- Designed Rainbow Schlieren Deflectometry (RSD) setup to study pre-mixed flame flickering in burners.
- Worked on Particle Image Velocimetry (PIV) of buoyant jets in a channel to understand plume-separation dynamics using ultra-fine seeding particles.

Summer Intern, Visiting Students' Research Programme (VSRP) *May – July 2010*
Tata Institute of Fundamental Research (TIFR), *Mumbai, India*

- Project: "Orientation of solid objects freefalling in water at low Reynolds Number".
- Showed that non-spherical bodies changed orientation only during the accelerating phase of free-fall through a water column; which helped Mumbai Municipal Water Works tackle sedimentation problems.

Summer Intern, Summer Research Fellowship Programme (SRFP) *May – July 2009*

Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR), *Bangalore, India*

- Project: "A Study of Air Flow and Particle Deposition in Modelled Airway of Human Lung".
- Aerosols sized <5μm moved with flow and ~10μm were prematurely deposited; ~7.5μm were efficient for effective drug delivery as 50-60% of the particles injected impacted lung walls.

SKILLS

- Computer languages: C, C++ (12 years), Fortran (6 years), Python (2 years)
- CFD softwares: OpenFOAM (8 years), ANSYS Fluent (2 years), StarCCM (1 year), Converge (1 year) and recently Nek5000 & NekRS
- Mesh and grid generation packages: ICEM-CFD (7 years), Cubit (2 years)
- Matlab (coding, plotting, image-processing, Simulink for 10 years)
- Plotting softwares: Tecplot, Paraview, Visit, Gnuplot
- Other softwares: ChemKin, Cantera, Solid Works and preCICE (code-coupling)
- In-house codes: PDF model for turbulent-combustion (Penn State), RTE solvers (Penn State), PRATHAM LBM code (ORNL), FRESCO combustion code (ORNL)

PUBLICATIONS AND CONFERENCE PROCEEDINGS

- "MHD turbulence models for fusion reactor blankets", A. Sircar, V. Badalassi, APS-DFD Conference, November 20 – 22, Indianapolis, 2022.
- "Multiphysics code coupling for fusion blankets", A. Sircar, K. Borowiec, J. W. Bae, J. Solberg, V. Badalassi, ANS Winter Meeting, November 13 – 17, Phoenix, 2022.
- "FERMI: Fusion Energy Reactor Models Integrator", V. Badalassi, A. Sircar, J. W. Bae, K. Borowiec, S. Smolentsev, J. M. Solberg, P. Huang, submitted to special issue of Fusion Science and Technology on large-scale fusion systems analysis after invitation.
- "FERMI: A multi-physics simulation environment for Fusion reactors blanket.", A. Sircar, J. W. Bae, V. Badalassi, E. Peterson, J. Solberg, NURETH-19, Belgium, March 6-11, 2022.
- "Advanced finite-volume numerics and source term assumptions for G-Equation modelling of propane/air flames", F. Perini, F. Chuahy, A. Sircar, D. Splitter, R. Reitz, SAE Technical Paper, 2022.
- "Multiphysics simulations for fusion reactor blankets", A. Sircar, J. W. Bae, V. Badalassi, ANS Winter Meeting, November 30 – December 2, 2021.
- "Turbulent flow and heat flux analysis from validated large eddy simulations of flow past a heated cylinder in the near wake region", A. Sircar, M. Kimber, S. Rokkam, G. Botha, Phys. Fluids 32 (2020, selected as Editor's Pick)
- "Soot and spectral radiation modeling for high-pressure turbulent spray flames", S. Fernandez, C. Paul, A. Sircar et al., Combustion and Flame Volume, 190, April 2018, Pages 402-415.
- "An assessment of CFD based wall heat transfer models in piston engines", A. Sircar, C. Paul et al., 10th US National Combustion Meeting, April 2017, College Park, MD.
- "Modeling Radiative Heat Transfer and Turbulence-Radiation Interactions in Engines", C. Paul, A. Sircar et al., 10th US National Combustion Meeting, April 2017, College Park. MD.
- "Turbulence Radiation coupling in boundary layers of heavy-duty diesel engines", A. Sircar, C. Paul et al., SIAM International Conference on Numerical Combustion, April 2017, Orlando.
- "Coupling between Turbulent Boundary Layer and Radiative Heat Transfer under engine-relevant conditions", A. Sircar, C. Paul et al., APS Division of Fluid Dynamics, November 2016, Portland.

- "Modeling Radiative Heat Transfer in Engines", D. C. Haworth, S. P. Roy, J. Cai, A. Sircar, M. F. Modest, International Multidimensional Engine Modeling Meeting, SAE Congress 2015, Detroit.
- "A Study of Air Flow and Particle Deposition in Modeled Airway of Human Lung", Arpan Sircar, Mohan D Deshpande, Vinay Ballal. ANSYS India conference 2010, Bangalore.

PEER REVIEW AND SESSION CHAIRS

- Peer-reviewed journals for Physics of Fluids (4), SAE (4), MDPI (20) – Fluids, Energy, Fuel (2)
- Internal ORNL reviewer for one publication from the Computational Sciences Division
- Session Chair for the Magnetohydrodynamics session at APS-DFD 2022, Indianapolis.

SPECIAL MENTION

- Technology demonstration of FERMI using Augmented Reality at ARPA-E Summit in Colorado, 2022.
- Attended the preCICE workshop in 2021 and 2022 with a user talk on volumetric coupling in 2022.
- Supervised UG students at TAMU on CFD techniques and performing data analysis using POD.
- Attended talks on turbulent combustion in the 2015 and 2016 Princeton Combustion Summer School.
- Teaching assistant at IIT – Mathematical Methods in Engineering and Computational Fluid Dynamics.
- Past student member of ISHRAE (Indian Society of Heating Refrigeration and Airconditioning Engineers), ASME (American Society of Mechanical Engineers) and the Combustion Institute; current members of SAE (Society of Automotive Engineers) and ANS (American Nuclear Society).