Daipayan Sen

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PhD Candidate, Mechanical Engineering | University of Minnesota – Twin Cities

Professional Summary

PhD candidate in Mechanical Engineering with 5+ years of combined academic and research experience in multiphase transport phenomena, heat and mass transfer, and combustion systems. Hands-on experience in developing custom experimental setups with a track record in high-fidelity multiphysics simulations. Passionate about applying heat and mass transfer fundamentals for designing energy-efficient technologies, next-generation thermofluidic systems, process intensification, and decarbonization.

Education

University of Minnesota – Twin Cities (UMN–TC) — Minneapolis, MN
Ph.D., Mechanical Engineering (*Sep 2022 – 2027 (tentative)*) — GPA: 3.78/4.00
M.S., Mechanical Engineering (*Sep 2022 – Jun 2024*) — GPA: 3.77/4.00

Jadavpur University (JU) — Kolkata, India
B.E., Mechanical Engineering (*Jul 2017 – Jul 2021*) — GPA: 9.12/10.00

Technical Skills

Experimental & Diagnostics: Optical diagnostics (IR thermography, Schlieren, chemiluminescence, high-speed direct imaging, TDLAS, SEM), standardized material testing (tensile, torsion, fold endurance, tear resistance), aerosol measurement techniques (APS, SMPS, CPC), transducers (thermocouples, pressure, acoustic), NI cDAQ/DAQ, PID control, laboratory automation.

Modeling & Simulation: COMSOL Multiphysics, ANSYS Fluent, STAR-CCM+, CHEMKIN.

Programming & Data Tools: MATLAB (image processing, data fitting, etc), Python, LabVIEW, VBA/Excel automation, TECPLOT, ImageJ.

CAD & Design: SolidWorks, AutoCAD, DesignModeler; prototyping, machining, GD&T, FMEA.

Work Experience

Graduate Research Assistant, *Biobased Process & Products Engineering Lab* — UMN–TC | May 2024 – Present

- Designed and executed wind-tunnel drying experiments on wet porous biomaterials (e.g., pulp, corn) under convective, conductive, RF heating, and ultrasonic agitation. Implemented IR thermography and laser-based moisture sensing for capturing transient moisture and temperature histories.
- Performed complex permittivity measurements of biomaterials under varying temperatures (25 - 90°C) and moisture contents (0 - 50%), using coaxial probe measurement techniques. Designed and fabricated a temperature and humidity controlled sample holder to perform corresponding experiments.
- Reduced variability in experimental data by modifying and upgrading existing experimental techniques, such as optimized sample holder design, minimization of flow separation under convective wind, and thermal energy loss from the sample.
- Modeled drying cycles in a Fourdrinier machine by implementing multiphase heat and mass transfer simulations of hygroscopic porous materials, incorporating fundamental physics such as bound water removal, capillarity, diffusion in COMSOL and STAR-CCM+. Incorporated auxilliary energy application methods such as radiofrequency-assisted heating.
- Developed MATLAB and Excel-based data tracking and analysis tools for post-processing raw sensor and image data, calculating heat and mass transfer coefficients, and estimating error and variability.

Graduate Research Assistant, *Murphy Engine Research Laboratory (MERL)* — UMN–TC | Sep 2022 – May 2024, June 2025 - Present

- Designed and assembled a unique optically-accessible 8L 100 bar combustion chamber with an optical prechamber; integrated thermocouples, pressure transducers, PID control, and NI cDAQ systems.
- Sized flowrate requirements, designed and implemented pre-mixing chambers for constant volume combustion vessels and turbine combustors.
- Implemented simultaneous high-speed imaging techniques—including direct, Schlieren, and radical-based chemiluminescence methods—to capture detailed flame propagation and jet formation dynamics.
- Collaborated with research and industry partners (Cooper Machinery Services, Texas A&M, University of Alabama, Vieletech, Colorado School of Mines, etc.), aligning experimental insights with applied engineering needs.

- Maintained and improved the continuity of high-pressure optical combustion chamber experiments by drafting SOPs, scheduling experiments, and training new researchers; reduced downtime and improved repeatability across team transitions.

Collaboration Lead, Machine Learning Projects Colorado School of Mines; Augusta University | April 2025 – Present

- Coordinated multi-institution research on machine learning for sustainable aviation fuels and flame edge detection; established standardized datasets, processed raw image data for training, and implemented shared code review practices to ensure reproducibility across groups.

Research Assistant, *Neptune (CFD) Laboratory* JU | Jul 2018 – May 2022

- Simulated fluid flow through porous multibody systems with Darcy–Brinkman–Forchheimer formulations using ANSYS Fluent. Implemented user-defined functions for custom source terms and property models.
- Analyzed irreversibilities and entropy generation through evaluation of non-dimensional numbers (Nusselt, Bejan, Darcy, etc).
- Developed and modeled 3D tubular networks to replicate human trachea. Performed multiphase simulations in the branching networks to examine the degree of deposition of foreign matter during inhalation and exhalation.

Teaching & Mentorship

Graduate Teaching Assistant, Energy Conversion Systems Laboratory UMN–TC | Sep 2023 – Dec 2023
Supervised laboratory sessions on gas turbines, compressors, and fuel cells; coached students on experimental safety, root-cause analysis, and data-driven decision-making; organized departmental poster session and mentored teams to communicate results effectively.

Student Research Mentor UMN–TC | Jan 2023 – Present
Trained and supervised incoming undergraduate and high school interns, providing hands-on guidance in experimental techniques and safe laboratory operation, contributing to smooth integration into ongoing research projects.

Achievements & Recognition

- Finalist in AIChE FPB Graduate Student Award 2025.
- Graduated ranked 6th in the Mechanical Engineering Class of 2021, Jadavpur University.
- 2nd Place, "Arms Ready" Hydraulic-Arm Design Challenge, Trajectory 2.0 Tech Fest, Jadavpur University, 2018.

Publications & Presentations

Journal Articles

1. **Sen, D.**, Sampath, K., Huang, H., & Ramaswamy, S. "Multiphysics simulation and experimental validation of convective drying of hygroscopic porous biomaterials," *International Journal of Heat and Mass Transfer*, 256, 128128, 2026. DOI
2. Ahmed, T., Rajaganapathy, S., Patanjali, SLPSK., **Sen, D.**, Dhotre, A., Srna, A., Lee, T., Buchanan, K., & Rajasegar, R. "Machine Learning-Augmented Flame Front Detection in High-Speed Imaging: A Physics-Guided Framework," *AIAA SciTech*, 2026.
3. Sampath, K., Huang, H., **Sen, D.**, & Ramaswamy, S. "Process intensification approach to enhancing heat and mass transfer: Radio frequency (RF) assisted drying of paper and board," *International Journal of Thermal Sciences*, 217, 110069, 2025. DOI
4. Buchanan, K., Dhotre, A., Sen, D., Srna, A., & Rajasegar, R. (2025). Interaction and ignition process of multiple injections of oxygenated fuels in an optical, heavy-duty diesel engine. *Proceedings of the Combustion Institute*, 41, 105820. DOI
5. **Sen, D.**, & Biswas, S. "Optical prechamber-equipped high-pressure large-bore optical combustor for fundamental combustion studies," *Review of Scientific Instruments*, 96(3), 034901, 2025. DOI
6. **Sen, D.**, Ghosh, A., Chakravarty, A., Sarkar, S., Manna, N. K., Ghosh, K., & Mukhopadhyay, A. "Forced convection and entropy generation past a series of porous bodies with internal heat generation," *Physica Scripta*, 96(12), 125009, 2021. DOI
7. Ghosh, A., **Sen, D.**, Manna, N. K., & Sarkar, S. (2021). Multiphase dynamics in a three dimensional branching network. IOP Conference Series: Materials Science and Engineering, 1080(1), 012041. DOI

Posters & Presentations

1. Modeling of paper drying under convective and RF energy applications, *AIChE Annual Meeting*, 2025. (Presenter)
2. Modeling of paper drying under conventional and RF energy applications, *TAPPICon*, 2025. (Presenter)
3. Turbulent Jet Ignition using Nanosecond Pulsed Discharge in An Optical Constant Volume Chamber, *Spring Technical Meeting of the Central States Section of The Combustion Institute*, 2024. (Prepared)

4. Non-thermal plasma-assisted pre-chamber ignition of methane/air for natural gas compressor station application, *SAE WCX*, 2024. (Presenter)
5. Prechamber-equipped Optical Constant Volume Combustion Chamber, *13th US National Combustion Meeting*, 2023. (Presenter)
6. Multiphase dynamics in a three dimensional branching network, *3rd International Conference on Advances in Mechanical Engineering and its Interdisciplinary Areas*, 2021. (Prepared)