

Dhananjay Kumar, Ph.D.

Mechanical Engineer | CFD & Thermal Systems Researcher | Hydrogen Combustion, Battery Thermal Runaway, and Low-Carbon Fuel Engines

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PROFILE

CFD and thermal systems researcher with a Ph.D. in Mechanical Engineering from IIT Kanpur and ongoing postdoctoral work at the University of Wisconsin-Madison Engine Research Center. Specializes in hydrogen and low-carbon fuel combustion, lithium-ion battery thermal runaway, and optical diagnostics, combining hands-on experimental work (constant volume combustion chamber testing, Schlieren and shadowgraphy imaging, engine test cells) with high-fidelity CFD modeling in CONVERGE and GT-Power. Author of 40+ peer-reviewed journal papers, conference papers, and book chapters, including 2 edited Springer volumes and 2 Indian patents (1 granted), with 403+ citations and an h-index of 11. Builds software as well as publishes papers, most recently AgniCycle, a real-time zero-dimensional IC engine simulator taken from physics model through cloud deployment. Open to faculty positions as a primary path, with applied CFD and thermal/battery simulation roles in industry as a parallel track.

RESEARCH INTERESTS

- Hydrogen combustion and H2/CNG/HCNG engine development and prototyping
- Optical diagnostics: Schlieren imaging, diffused back-illumination (DBI), and shadowgraphy
- Alternative fuels (hydrogen, CNG, methanol, ethanol)
- Battery thermal management and thermal runaway
- Chamber combustion and spray characterization
- Turbulent combustion modeling

EDUCATION

Degree	Field	Years	Institution
Postdoctoral Research Associate	Mechanical Engineering	2024 to present	University of Wisconsin-Madison, USA
M.Tech + Ph.D.	Mechanical Engineering	2017 to 2024 (CGPA 7.4/10)	Indian Institute of Technology Kanpur, India
B.Tech	Mechanical Engineering	2013 to 2017 (CGPA 8.33/10)	National Institute of Technology Mizoram, India

Ph.D. dissertation: *Spray, Laser Ignition, Combustion and Engine Investigations of Low Carbon Fuels*. Advisor: Prof. Avinash Kumar Agarwal, IIT Kanpur (2017 to 2024)

M.Tech dissertation: *Simulation of High-Pressure Co-Axial Injection System for Methanol Adaptation in a Locomotive Engine*. Advisor: Prof. Avinash Kumar Agarwal, IIT Kanpur (2021)

RESEARCH EXPERIENCE

Postdoctoral Research Associate, University of Wisconsin-Madison (October 2024 to present)

Project 1: Solid Particle Ejection and Vent Gas Ignition During Battery Thermal Runaway Events

Funding: Ford Motor USA. Advisors: Prof. Sage Kokjohn (PI), UW-Madison; Ben Petersen, Research Engineer, Ford Motor Company
Thermal runaway modeling of Li-ion batteries using CONVERGE CFD, custom UDFs, and Auto-Lion

Project 2: Large-Survey-Area H2 Leak Detector Based on a Quadcopter-Mounted Laser Imager

Funding: Advanced Research Projects Agency-Energy (ARPA-E), U.S. Department of Energy. Advisors: Prof. Sage Kokjohn (Co-PI) and Prof. Scott Sanders (PI), UW-Madison

Hydrogen leak simulation in CONVERGE CFD using the iBAGI technique; grid independence and stationarity analysis across multiple AMR mesh resolutions

Ph.D. Researcher, IIT Kanpur (August 2017 to September 2024)

Thesis: *Spray, Laser Ignition, Combustion and Engine Investigations of Low Carbon Fuels*, advised by Prof. Avinash Kumar Agarwal

- Characterized flame kernel propagation of hydrogen and hydrogen-enriched CNG in a constant volume combustion chamber
- Studied spray characteristics of hydrogen, CNG, methanol, ethanol, and gasoline
- Developed laser ignition systems for gaseous and liquid fuels, including engine modification and ECU calibration for alternative fuels
- Characterized engine performance, combustion, emissions, and particulates across fuel blends

M.Tech Researcher, IIT Kanpur (2021)

Thesis: *Simulation of High-Pressure Co-Axial Injection System for Methanol Adaptation in a Locomotive Engine*, advised by Prof. Avinash Kumar Agarwal

- Built and validated a 1D GT-Power model against diesel fueling data
- Ran a feasibility study for methanol-fueled adaptation of a locomotive engine, with spray modeling in CONVERGE CFD

SELECTED PROJECTS

AgniCycle — Real-time zero-dimensional IC engine simulator agnicycle.com (*pre-launch*)

- Designed and deployed a browser-based, real-time OD engine simulation tool on Google Cloud Run covering combustion, cylinder

pressure, and performance prediction

- Audited the simulator's thermodynamics against an exported dataset, identifying and correcting a heuristic peak-pressure multiplier in favor of a first-law-consistent pressure model
- Built out the full product surface: branding, Firebase Authentication, GA4 analytics, and a public portfolio presence

Spray Calculator A standalone fuel injection and spray atomization analysis tool, developed alongside AgniCycle

INTERNATIONAL EXPOSURE

South Korea (November 30 to December 12, 2021): Two-week collaborative visit with Konkuk University and Hanyang University on *Prototype Development and Experimental Investigations of CNG Fueled Direct Injection Spark Ignition Engine*. Worked on Schlieren imaging setup for CNG spray and CONVERGE case setup, under Prof. Suhan Park (Konkuk University) and Prof. Sungwook Park (Hanyang University)

United Kingdom (August 13 to 23, 2023): Presented *Experimental Assessment of Spray Characteristics of Hydrogen and CNG Using Schlieren Imaging* at SET-2023 (20th International Conference on Sustainable Energy Technologies), organized by WSSET and the University of Nottingham. Visited the Engine Lab at the University of Oxford, Department of Engineering Science, hosted by Prof. Richard Stone

TECHNICAL SKILLS

Simulation Software: Proficient: CONVERGE CFD, GT-Power, SolidWorks, Tecplot, Origin. Working knowledge: Ansys Fluent, OpenFOAM, Cantera, Chemkin, Auto-Lion, EnSight

Programming: Python, MATLAB, C++, LabVIEW

Cloud & Web: Google Cloud Run, Firebase, Google Analytics (GA4)

Experimental & Instrumentation: Constant volume combustion chamber (CVCC) and spray setup development; Shadowgraphy, Mie-scattering, and Schlieren imaging setup development; test engine and experimental setup preparation, wiring harnesses; ECU calibration and in-cylinder combustion diagnostics; microscopic and macroscopic spray analysis; DAQ systems (Synergy, AVL); emission analyzers (AVL, Horiba)

PUBLICATIONS

Peer-Reviewed Journal Articles

1. Kumar D, Agarwal AK. Laser ignition versus conventional spark ignition system performance for hydrogen-enriched natural gas-air mixtures in a constant volume combustion chamber. *Applied Thermal Engineering*. 2024;257:123988.
2. Kumar D, Agarwal AK. Effects of initial chamber pressure, temperature and mixture strength on combustion and flame kernel propagation in hydrogen and natural gas-air mixtures. *Energy Conversion and Management*. 2024;315:118654.
3. Kumar D, Pradeep P, Agarwal AK. Macroscopic jet characteristics of hydrogen and natural gas in direct injection spark ignition engine-like conditions. *International Journal of Hydrogen Energy*. 2024;80:1328 to 1338.
4. Kumar D, Agarwal AK. Macroscopic spray characteristics of gasoline, methanol, and ethanol in direct injection spark ignition engine-like conditions. *Atomization and Sprays*. 2023;33(11).
5. Kumar D, Sonawane U, Chandra K, Agarwal AK. Experimental investigations of methanol fumigation via port fuel injection in preheated intake air in a single cylinder dual-fuel diesel engine. *Fuel*. 2022;324:124340.
6. Valera H, Kumar D, Agarwal AK. Evaluating the effect of variable methanol injection timings in a novel co-axial fuel injection system equipped locomotive engine. *Journal of Cleaner Production*. 2022;349:131452.
7. Kumar D, Valera H, Gautam A, Agarwal AK. Simulations of methanol-fueled locomotive engines using a high-pressure co-axial direct injection system. *Fuel*. 2021;295:120231.
8. Pham Q, Kumar D, Agarwal AK, Park S. Numerical modeling of macroscopic and dynamic jet characteristics of low-carbon fuels: hydrogen, CNG, and blends in direct-injection spark ignition engine-like conditions. *Fuel*. 2026;412:138144.
9. Singh AP, Kumar D, Agarwal AK. Particulate characteristics of laser ignited hydrogen-enriched compressed natural gas engine. *International Journal of Hydrogen Energy*. 2020.
10. Curran S, et al., Kumar D, et al. The future of ship engines: renewable fuels and enabling technologies for decarbonisation. *International Journal of Engine Research*. 2023.

Full record (10 international journal papers, 2 national journal papers, 7 book chapters, 2 edited Springer volumes, 403+ citations, h-index 11, i10-index 12) on Google Scholar.

Edited Volumes

- *Engine Modeling and Simulation*. Agarwal AK, Kumar D, Sharma N, Sonawane U (eds.). Springer, 2022
- *Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines*. Singh AP, Kumar D, Agarwal AK (eds.). Springer, 2021

Forthcoming

- Co-editor, *Hydrogen as an Energy Carrier and Combustion Fuel: Enabling the Future of Mobility and Power* (Springer, in preparation with the ISEES editorial team)

Manuscripts in Preparation

- Kumar D, Petersen B, Kokjohn S. Solid Particle Ejection and Vent Gas Ignition During Battery Thermal Runaway Events
- Kumar D, Beuting M, Sanders S, Kokjohn S. CFD Modeling of Large Scale Hydrogen Leaks

Patents

- *High-Pressure Coaxial Direct Injection System for an Internal Combustion Engine*. Indian Patent Office, Application No. 202411037969, Patent No. 589697, filed May 14, 2024, granted 2026. Inventors: Avinash Kumar Agarwal, Hardikk Valera, Dhananjay Kumar
- *A Supplementary Fuel Intake Assembly for an Engine*. Indian Patent Office, Application No. 202411037965, filed May 14, 2024 (under review). Inventors: Avinash Kumar Agarwal, Dhananjay Kumar, U. Sonawane

Conference Presentations

- Experimental Assessment of Spray Characteristics of Hydrogen and CNG Using Schlieren Imaging, SET2023 (August 2023)
- Comparative Assessment of Macroscopic Spray Characteristics for the Direct-Injected Spray of Gasoline, Methanol, and Ethanol in SI Engine-Like Conditions, ILASS Asia-2022, IIT Indore (October 2022)
- Numerical Predictions of In-Cylinder Phenomena in Methanol-Fueled Locomotive Engine Using High-Pressure DI Technique, SAE Technical Paper (2021)
- Feasibility Assessment of Methanol Fueling in Two-Wheeler Engine Using 1-D Simulations, SAE Technical Paper 2021-01-0382 (2021)
- Assessment of Methanol Fueling in ALCO-251 Locomotive Engine Using Simulation Approach (poster), KAUST hybrid conference (June 2021)
- Particulate Matter Investigation of Different Blends of Hydrogen Enriched CNG Laser Ignited Engine, IV-SEEC, NEERI Nagpur (November 2019)
- 1-D Modelling and Simulation of 4-Cylinder 4-Stroke SI Engine Using GT-Suite, III-SEEC, IIT Roorkee (December 2018)

AWARDS AND HONORS

- Best M.Tech. Thesis Award, International Society for Energy, Environment and Sustainability (ISEES), December 2021
- Best Paper Presentation Award in Track, III-SEEC, IIT Roorkee, December 2018
- Best Tutor, ESO201A (Thermodynamics), IIT Kanpur, Odd Semester 2023
- Internship, IIT Guwahati, under the Ishan Vikas Program of MHRD, July 2016

PROFESSIONAL MEMBERSHIPS AND SERVICE

- Executive Committee Member and Treasurer, International Society for Energy, Environment and Sustainability (ISEES), 2021 to 2024
- Executive Committee Member, ISEES, 2019 to 2021
- Member, Society of Automotive Engineers (SAE)
- Member, American Society of Mechanical Engineers (ASME)
- Reviewer: *Fuel*, *International Journal of Hydrogen Energy*, *Energy*, ASME Journal of Thermal Science and Engineering Applications, ASME Journal of Engineering for Gas Turbines and Power, Springer Nature

LEADERSHIP

- President, Alumni Council, NIT Mizoram

REFERENCES

Available upon request.