# Pradeep Kumar Pavalavanni

## Research Scientist | Combustion and Explosion Modeling

Mobile: +1-763-346-5771 | Email: pkpavalavanni@gmail.com | LinkedIn: ppkaerospace
Ask me: https://cfdfire.pkpavalavanni.com/ (Interactive resume)

### SUMMARY

Combustion and explosion modeling engineer with 9+ years of post-graduate experience developing high-fidelity CFD and ML–based reduced-order models for industrial safety and engine applications. Proven track record of translating physics-based simulations into actionable engineering insights, including overpressure prediction, thermal risk assessment, and control-oriented modeling. Experienced in integrating CFD, experimental, and neural networks to enable real-time digital-twin frameworks for predictive analysis and decision-making.

### RELEVANT SKILLSET FOR UL SOLUTIONS

- **Explosion dynamics modeling:** Developed and validated high-fidelity reactive flow CFD models in OpenFOAM for deflagration, detonation for industrial fire scenarios, integrating turbulence-reaction chemistry and experimental benchmarking.
- **Model validation and Integration:** Designed simulation- experiment validation protocols (multi-fuel capable ICEs) and cross-platform CFD workflows (Converge CFD and OpenFOAM) with python-based automation for model verification and implementation.
- **Battery Fire & Thermal Runaway Modeling:** Led CFD-based studies on LFP, NMC battery thermal runaway and vented deflagrations using Converge CFD. Created python code to extract reaction rate profiles from experiments for numerical simulation.
- **Reduced Order & Surrogate Modeling:** Successfully developed numerical framework and implemented Bi-Fidelity (CFD + Experiments) Neural Network model for quick turn around development time.
- **Computational Tools and Platforms:** FORTRAN, C/C++, Python, MATLAB; OpenFOAM, Converge CFD, FLACS, Ansys FLUENT; Digital Twins Frameworks; TensorFlow; HPC (Linux and Windows-based clusters); Windows/Linux environments; MPI/OpenMP.

### PROFESSIONAL EXPERIENCE

**Nov 2022 — Present** **Research Scientist / Postdoctoral Research Associate**
Computational Reactive Flow and Energy Lab
University of Minnesota — Twin Cities, USA

- Led development of **ML-accelerated multiphysics** combustion workflows, reducing CFD runtimes while preserving thermodynamic fidelity and enabling faster evaluation of engine performance and safety-critical combustion behavior.
- **Designed end-to-end CFD–experiment validation pipelines**, improving model reliability and supporting predictive assessment of combustion behavior for engine development and control applications.
- Developed a computational **framework to calculate reaction rates during thermal runaway** using **experimental data**, providing stakeholders with structured inputs for battery fire modeling.
- Developed and deployed **bi-fidelity neural-network surrogate models (CFD + experimental data)**, enabling faster prediction of combustion characteristics for digital twin environments and rapid engineering decision-making.
- Collaborated with international and domestic cross-functional teams (CFD, experimental, and controls) to implement solvers, validate models, and develop and deploy ROMs for control-oriented and digital twin applications.

**Sept 2021 — Oct 2022** **Major Hazards Management Team**
Technical Safety Engineer – Major Hazards Management
Shell Technology Centre, Bangalore, India

- Performed risk-informed CFD simulations of **large-scale vapor cloud explosions** and **industrial fire** scenarios using FLACS and OpenFOAM-based solvers, capturing turbulence–chemistry interactions, pressure wave propagation, and flame acceleration to evaluate hazard severity.
- **Co-developed and enhanced PDRFOAM-R**, a compressible turbulent reactive-flow solver, incorporating large-scale experimental data, instrumentation constraints, and boundary-condition uncertainties to improve model reliability for industrial explosion risk assessment.
- Quantified thermal radiation loads, overpressure effects, and ignition sensitivity to assess fire and explosion hazards, supporting safety-critical engineering decisions and loss prevention strategies.

**Feb 2021 — Sept 2021** **Career Break**
(Personal commitments)

- Traveled internationally to fulfill **personal and family commitments** following Ph.D. completion.
- **Maintained engagement with research activities**, including remote presentation at an **AIAA Propulsion and Energy Forum**

## EDUCATION

**2015–2021** **Doctor of Philosophy**
Aerospace Engineering
Pusan National University, Busan, Republic of Korea

**2013–2015** **Master of Science**
Aerospace Engineering
Pusan National University, Busan, Republic of Korea

**2008–2012** **Bachelor of Engineering**
Aeronautical Engineering
Anna University, Tamil Nadu, India

## GRADUATE RESEARCH EXPERIENCE

**2017 — 2021** **Rocket Propulsion Laboratory**
Graduate Researcher
Pusan National University, Busan, South Korea

- **Developed and validated high-resolution compressible reacting-flow solvers** in Fortran, incorporating **detailed chemical kinetics and advanced shock-capturing schemes** for detonation and shock-induced combustion.
- Performed numerical stability analysis, resolution sensitivity studies, and kinetic mechanism benchmarking to balance fidelity vs computational cost.
- **Proposed a novel bifurcation mechanism** to advance the fundamental understanding of detonation wave propagation, elucidating the **coupling between shock dynamics, ignition chemistry, and heat-release processes** through detailed kinetic simulations and mode analysis.
- Developed **physics-based diagnostics** including **Chemical Explosive Mode Analysis** (CEMA) and **Dynamic Mode Decomposition** (DMD) to characterize instability and transient detonation structures.

## SCIENTIFIC COMMUNICATIONS

### Peer-reviewed Journals

1. P.K. Pavalavanni., M-S Jo., J-E. Kim., J.-Y. Choi (2023). “Numerical Investigation of the Detonation Cell Bifurcation with Decomposition Technique”. Aerospace, 10(3), 318.
2. P.K. Pavalavanni., M-S Jo., J-E. Kim., J.-Y. Choi (2023). “Numerical Study of Unstable Shock-Induced Combustion with Different Chemical Kinetics and Investigation of the Instability Using Modal Decomposition Technique”. Aerospace, 10(3), 292.
3. M. Nejaamtheen., T-Y. Kim., P.K. Pavalavanni., J.H. Ryu., J.-Y. Choi (2021). “Effects of the Dimensionless Radius of an Annulus on the Detonation Propagation Characteristics in Circular and Non-Circular Rotating Detonation Engines”. Shock Waves, 31(7): 703–715.
4. P.K. Pavalavanni., C.H. Sohn, B.J. Lee, J.-Y. Choi (2019). "Revisiting Unsteady Shock-Induced Combustion with Modern Analysis Techniques." Proceedings of the Combustion Institute, 37(3): 3637–3644.
5. P.K. Pavalavanni., J.-Y. Choi, J. Son, H.S. Chae (2017). "Applications of Dynamic Mode Decomposition to Unstable Shock-Induced Combustion." Journal of the Korean Society of Propulsion Engineers, 21(2): 9–17.
6. P.K. Pavalavanni., K.-S. Kim, S. Oh, J.-Y. Choi (2015). "Numerical Comparison of Hydrogen-Air Reaction Mechanisms for Unsteady Shock-Induced Combustion Applications." Journal of Mechanical Science and Technology, 29(3): 893–898.

### Manuscript in preparation:

7. P.K. Pavalavanni., et al. (2026). “Development of a bi-fidelity neural network surrogate framework and its application to feed-forward control of multi-fuel energy-assisted compression ignition engines.”.
8. P.K. Pavalavanni, et al. (2026). "Layered Multi-Input Neural Networks for Cross-Dimensional Data Assimilation and High-Dimensional Engine Control Testing" In progress.

### International Conferences (recent and relevant)

1. P.K. Pavalavanni., et al. (2026). “A Feature-Focused Neural Network based Bi-Fidelity Surrogate Model for Combustion Prediction in Aerial Internal Combustion Engines”. AIAA SciTech 2026 Forum.
2. Sai Ranjeet Narayanan., P.K. Pavalavanni., et al. (2026). “Numerical modeling of spark ignition in aerial internal combustion engines using low cetane number sustainable aviation fuels”. AIAA SciTech 2026 Forum
3. Praise Noah Johnson., P.K. Pavalavanni., et al. (2026). “Modeling of Plasma Ignition of Low Cetane Fuels in an Aerial Internal Combustion Engine”. AIAA SciTech 2026 Forum.
4. P.K. Pavalavanni., et al. (2025). “Bi-Fidelity Neural Network Model for Multi-Fuel Capable Internal Combustion Engines”. AIAA SciTech 2025 Forum.
5. P.K. Pavalavanni., et al. (2024). “Numerical Modeling of Energy Assisted Compression Ignition Engines for Aerial Operations”. AIAA SciTech 2024 Forum.
6. S. Raghunath., P. Sathiah., P.K. Pavalavanni (2022). “Progress in CFD Simulation of Deflagration using PDRFOAM”. HAZARDS32 Process Safety Conference.
7. P.K. Pavalavanni., J. Ryu, J.-Y. Choi (2021). “Dynamic Mode Decomposition Analysis of the Detonation Cell-Bifurcation Process”. AIAA Propulsion and Energy Forum.