CP PREMCHAND

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Education

Indian Institute of Technology Bombay (IITB) Jul 2016 – Feb 2022
Doctor of Philosophy (direct Ph.D.) *Mumbai, India*
Dissertation topic: "Intermittent Sound Sources in a Confined Flow Field"

Anna University (PCET-Coimbatore), Chennai, India Aug 2010 – May 2014
Bachelor of Engineering in Aeronautical Engineering *Coimbatore, India*

Experience

University of Tennessee Space Institute (UTSI) Sept 2023 – ongoing
Post Doctoral Research Associate *Tennessee, USA*

Indian Institute of Technology Bombay (IIT-B) May 2022 – Jan 2023
Senior Research Fellow *Mumbai, India*

Indian Institute of Technology Bombay (IIT-B) Apr 2021 – Mar 2022
Post Doctoral Fellow *Mumbai, India*

Indian Institute of Technology Bombay (IIT-B) Jul 2016 – Mar 2021
Teaching Assistantship (through Project) *Mumbai, India*

Indian Institute of Technology Madras (IIT-M) Sep 2015 – Jun 2016
Project Assistant *Chennai, India*

Defence Research and Development Establishment (DRDO-GTRE, Bengaluru) Jun 2015 – Aug 2015
Apprenticeship Trainee *Bengaluru, India*

ISRO-Vikram Sarabhai Space Center (VSSC) Nov 2013 – Dec 2013
Internship *Thiruvananthapuram, India*

Projects

Post Doctoral Research : "Experiments on fully premixed hydrogen/air swirling flames"

Decarbonization and transient sequences in fully premixed hydrogen/air swirl flames : Explored decarbonization strategies through hydrogen-based energy systems by studying transient sequences of lean blowout, blowoff, and flashback using high-speed direct flame imaging. Documented these sequences from a 100% H_2/Air stabilized condition, depicted on a regime map as a function of equivalence ratio and bulk velocity, considering the evolution of Karlovitz and Lewis numbers. Acquired data on a fully premixed, hydrogen/air, swirl-stabilized laboratory-scale experiment using a high-speed camera sensitive to both UV and visible light to capture flame chemiluminescence, complemented by schlieren imaging. Analyzed the effects of preferential diffusion versus turbulence on flame wrinkling and discussed the relationship between photon counts and flame intensity amplitude. Aimed to enhance the understanding of unsteady processes in hydrogen premixed flames (Palies and Premchand [1], Premchand and Palies - abstract-reviewed conference [1].

Research on ignition of hydrogen/air and methane/air premixed flames : Conducted laboratory-scale experiments to investigate the ignition of hydrogen/air and methane/air premixed flames. Focused on characterizing the ignition transient sequence by comparing the effects of fuel type, equivalence ratio, bulk velocity, and geometry (bluff-body vs. swirler). Utilized high-speed flame chemiluminescence imaging and schlieren imaging to capture the transient evolution of the flame at bulk velocities ranging from 5 to 15 m/s in the lean equivalence ratio range. Generated integrated flame light time-series to estimate ignition delay time and compared results with existing literature. Documented high-speed schlieren imaging at up to 140,000 fps to capture the spark ignition dynamic sequence for three specific cases, characterizing the ignition transient sequences leading to stabilized flames in the premixed turbulent combustion flamelet regime near unity Karlovitz number (Tiwari *et. al* - conference [1]).

Ph.D. Research : "Intermittent Sound Sources in a Confined Flow Field"

In my dissertation, I investigated a thermoacoustic system (bluff-body stabilized turbulent combustor) and an aeroacoustic system (flow through two orifice plates kept at a distance). These systems produce oscillatory instabilities manifested as tonal sound that are detrimental in nature. Avoiding such oscillatory instabilities requires deep understanding about the root cause of the sound production. We explore the dynamics of coherent structures using Lagrangian coherent structures (LCS) to propose a possible mechanism leading to tonal sound production (Journal papers: Premchand *et. al* [5]). In the initial stage, a framework to extract Lagrangian coherent structures (in-house Matlab code) from the velocity flow-field is developed. Later, the framework of LCS is modified in Premchand *et. al* [2] to showcase only the LCS using mathematical conditions for the selection of appropriate contour levels.

Thermoacoustic system : We extracted Lagrangian coherent structure from the flow-field of bluff-body stabilized turbulent combustor to explore the dynamics of coherent structures. Through careful consideration, they are used to glean into the mechanisms of instability at operating conditions well before instability sets in (Journal papers: Premchand *et. al* [4] and [4]). A novel technique to extract coherent structures at a given frequency is also proposed by combining both dynamic mode decomposition (DMD) and Lagrangian coherent structures (LCS) framework. Later, we utilise the framework of Lagrangian coherent structures along with statistical analysis to identify the optimal location on tracked fluid (Lagrangian saddle point) trajectories to achieve control of instability (Journal paper: Premchand *et. al* [2]). Validation of the methodology will be performed by injecting a secondary micro-jet of air at the estimated optimal location to disrupt the observed trajectory of the identified Lagrangian saddle points. We will then compare and contrast the saddle point trajectories and the flow dynamics before and after control action.

Aeroacoustic system : We designed and fabricated an aeroacoustic setup to study the flow through two orifice plates kept at a distance. Initially, pressure measurements are acquired to perform a parametric study by varying the three parameters; (i) distance between the orifice plates, (ii) diameter and (iii) thickness of the orifice plates. We chose a best possible configuration to understand the mechanism of instability via flow dynamics. Particle image velocimetry (PIV) is performed on the selected configuration to obtain the flow-field. We then utilised the same framework explained in Premchand *et. al* [5] to extract Lagrangian coherent structures. The dynamics of coherent structures gave us a way to understand the mechanisms of instability well before instability sets in. We also performed statistical analysis to identify the optimal locations on the shear layer emerging from the lip of the orifice represented by the tracked fluid trajectories. We suggest that these optimal locations can be used for implementing passive and active control action.

Ongoing experimental projects |

1. "Experimental investigation on fully premixed hydrogen/air swirling flames - static stability"
   Experiments by **Premchand, C.P.** and Prof. Paul Palies in UTSI, USA;
   Measurements: Flame dynamics using high speed camera, schlieren and shadowgraph techniques
2. "Investigation of combustion instabilities in trapped vortex combustors"
   Designed by **Premchand C.P.**;
   Experiments by Ashutosh Singh and **Premchand, C.P.** in IIT-B, India;
   Measurements: Pressure fluctuations using piezoelectric transducers, global heat release rate fluctuations using CH* chemilumenscence, velocity flow-field using particle image velocimetry and OH-PLIF experiments.
3. "Experiments on controlling the oscillations in double orifice configuration (aeroacoustic system)"
   Designed by **Premchand C.P.** during Ph.D. tenure;
   Experiments by Ashutosh Singh and **Premchand, C.P.** in IIT-B, India ;
   Measurements: Pressure fluctuations using microphone, smoke visualisation, olive oil Mie-scattering and velocity flow-field using particle image velocimetry.

Research Interests

- Combustion dynamics
- Thermoacoustics
- Fluid dynamics
- Non-linear dynamics
- Aeroacoustics
- Turbulent flows

Technical Skills

Programing languages: Python, Matlab, C, C++, Fortran

Computational softwares: Ansys Fluent, COMSOL

Plotting softwares: Tecplot, Paraview, Gephi, QGIS

Modelling softwares: Solidworks, Autodesk Fusion, Catia, Autocad, Unigraphics

Measurement softwares: LabVIEW, Flowvision, PIVview, Phantom Camera Control (PCC), FASTCAM (Photran)

Chemical kinetics software: Cantera

References

1. **Prof. Vineeth Nair**, Associate Professor, Department of Aerospace Engineering, Indian Institute of Technology Bombay, Mumbai-400076, India. Prof. Vineeth Nair is my doctoral advisor and instructor for the course "Introduction to thermoacoustics".
   www.aero.iitb.ac.in/ vineeth/;. Email: vineeth@aero.iitb.ac.in;

2. **Prof. R. I. Sujith**, Institute Professor and D. Srinivasan Institute Chair Professor, Department of Aerospace Engineering, Indian Institute of Technology Madras, Chennai-600036, India. Prof. R. I. Sujith is one of our research collaborators. We have collaborated in projects focusing on thermoacoustic and aeroacoustic systems.
   www.ae.iitm.ac.in/ sujith/; Email: sujith@iitm.ac.in;

3. **Prof. A. M. Pradeep**, Professor, Department of Aerospace Engineering, Indian Institute of Technology Bombay, Powai, Mumbai-400076, India. Prof. A. M. Pradeep is a member of my Ph. D. Research Progress Committee and Post-doctoral Progress Committee at IIT Bombay.
   www.aero.iitb.ac.in/ ampradeep/; Email: ampradeep@aero.iitb.ac.in;

4. **Prof. Paul Palies**, Associate Professor, Department of Mechanical, Aerospace, & Biomedical Engineering (MABE), University of Tennessee Space Institute, Tullahoma, Tennessee - 37388, USA. I am currently working with Prof. Palies as a Post Doctoral Research Associate. We are working on fully premixed hydrogen based swirl stabilized combustor.
   www.utsi.edu/people/faculty/paul-palies/; Email: ppalies@utk.edu;

Honours/Awards/Certifications

- Recipient of the 2025 Turbo Expo Early Career Engineer Award (TEECE) from the International Gas Turbine Institute (IGTI) of ASME.
- Recipient of the 2021 Student Advisory Committee Travel Award (SACTA) from the International Gas Turbine Institute (IGTI) of ASME.
- Reviewer in Physics of Fluids, Chaos: An Interdisciplinary Journal of Nonlinear Science and student reviewer as a part of Student Paper Review Initiative for Turbo Expo 2021.
- Served as the Student Advisory Committee (SAC) student liaison for the Combustion, Fuels & Emissions Committee at ASME Turbo Expo 2021
- Memberships in American Society of Mechanical Engineers (ASME), American Physical Society (APS), American Institute of Aeronautics and Astronautics (AIAA)
- Received fellowships (Teaching Assistantship through Project) from the IRCC, IIT Bombay for direct Ph.D. programme (2016 - 2021). Grant Number: 16IRCCSG006
- Achieved a percentile score of 99.95 in the Graduate Aptitude Test in Engineering (GATE) entrance exams for Aerospace Engineering in both 2015 and 2016.

Teaching experience

Course code & name : AE 312 - Aerodynamics Laboratory Jan 2017 - Apr 2017
Undergraduate level (Spring semester) *Department of Aerospace Engineering, IIT-B, India*

Course code & name : AE 611 - Aerodynamics Laboratory Jul 2016 - Nov 2016
Postgraduate level (Fall semester) *Department of Aerospace Engineering, IIT-B, India*

Mentorship experience

Doctoral student (Ph.D.)

1. **Pratik Tiwari** — 2023 - 2024
   Faculty Advisor - Prof. Paul Palies — *UTSI, USA*

2. **Ashutosh Narayan Singh** — 2021 - 2023
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, India*

Master degree students (M.Tech)

1. **Gautam Kumar Jha** — 2020 - 2021
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, USA*

2. **Dharmendra Shaw** — 2019 - 2020
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, India*

Bachelor degree students (B.Tech/Dual degree)

1. **Isha Mukherjee** — 2022 - 2023
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, India*

2. **Gaurav Rathod** — 2022 - 2023
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, India*

3. **M. Vishnu Shankar** — 2021 - 2022
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, India*

4. **Ankit Choudhary** — 2019 - 2020
   Faculty Advisor - Prof. Vineeth Nair — *IIT-B, India*

List of publications

Peer-Reviewed Journal publications - published

1. Palies, Paul, and **Premchand, C.P.**, "Hydrogen-air lean premixed turbulent highly swirled flames stabilisation: experimental demonstration and mechanistic-kinematic description" The Aeronautical Journal - Cambridge University Press, pp. 1–24, (2025). https://doi.org/doi:10.1017/aer.2025.6.
2. **Premchand, C.P.**, Krishnan, A., Raghunathan, M., Midhun, P.R., Reeja, K.V., Sujith, R. I., and Nair, V., "Identifying optimal location for control of thermoacoustic instability through statistical analysis of saddle point trajectories", Chaos 34 (8), 083113-1 - 083113-13 (2024). https://doi.org/10.1063/5.0175991.
3. Roy, A., **Premchand, C. P.**, Raghunathan, M., Krishnan, A., Nair, V., and Sujith, R. I., "Critical region in the spatiotemporal dynamics of a turbulent thermoacoustic system and smart passive control", Combustion and Flame 226, 274-284 (2021). https://doi.org/10.1016/j.combustflame.2020.12.018
4. **Premchand, C. P.**, George, N. B., Raghunathan, M., Unni, V. R., Sujith, R. I., and Nair, V., "Lagrangian analysis of flame dynamics in the flow-field of a bluff-body stabilized combustor," Journal of Engineering for Gas Turbines and Power 142 (1), 011015 (2019). https://doi.org/10.1115/1.4044873
5. **Premchand, C. P.**, George, N. B., Raghunathan, M., Unni, V. R., Sujith, R. I., and Nair, V., "Lagrangian analysis of intermittent sound sources in the flow-field of a bluff-body stabilized combustor," Physics of Fluids 31 (2), 025115-1 - 025115-12 (2019). https://doi.org/10.1063/1.5064862

Journal publications - in-press and under preparation

1. Sahay A.,**Premchand, C.P.**, Meena, M.G., Nair, V., and Sujith, R.I., "Vortex pinch-off dynamics in turbulent thermoacoustic systems" (Manuscript under preparation).
2. Singh, A., **Premchand, C.P.**, and Nair, V., "Effectiveness of active and passive control in flow past the cavity flows" (Manuscript under preparation).
3. Singh, A., **Premchand, C.P.**, and Nair, V., "Experimental investigation of combustion instability in trapped vortex combustors" (Manuscript under preparation).
4. Thakare, P., **Premchand, C.P.**, Sinha, K., and Nair, V., "Lagrangian analysis of high intensity shock-turbulence interaction" (Manuscript under preparation).

Peer-Reviewed conference publications - published

1. Tiwari, Pratik, **Premchand, C.P.**, and Palies, Paul, "Ignition characteristics of fully premixed hydrogen/air and methane/air flames with high-speed chemiluminescence and schlieren imaging", ASME Turbo expo 2024, London, United Kingdom. Paper No: GT2024-129264, June 24-28, 2024. https://doi.org/10.1115/GT2024-129264
2. **Premchand, C.P.**, Raghunathan, M., Midhun, P.R., Reeja, K.V., Sujith, R. I., and Nair, V., "Smart passive control of thermoacoustic instability in a bluff-body stabilized combustor: A Lagrangian analysis of critical structures", ASME Turbo expo 2020, Virtual, Volume 4B, Paper No: GT2020-16073, September 21–22, 2020. https://doi.org/10.1115/GT2020-16073
3. **Premchand, C. P.**, George, N. B., Raghunathan, M., Unni, V. R., Sujith, R. I., and Nair, V., "Lagrangian saddle point analysis in the flow-field of a bluff-body stabilized combustor", ASME Turbo expo 2019, Phoenix, Arizona, USA, Volume 4B, Paper No: GT2019-91713, June 17–21, 2019. https://doi.org/10.1115/GT2019-91713

Abstract-Reviewed conference publications - published

1. **Premchand, C.P.**, and Palies, Paul, "Measurements of transient sequences for fully premixed hydrogen/air swirling flames", 77th Annual Meeting of the APS Division of Fluid Dynamics, Salt Lake City, Utah, USA, November 24-26, 2024. Preview abstract
2. Singh, A., **Premchand, C.P.**, and Nair, V., "Instability amplitude suppression in a double-orifice flow through external periodic forcing", Complexity and Nonlinear Dynamics in Science, Engineering, Technology and Mathematics (CNLDS-2023), IIT Hyderabad, 5-7 June 2023.

3. **Premchand, C.P.**, Krishnan, A., Raghunathan, M., Midhun, P.R., Reeja, K.V., Sujith, R. I., and Nair, V., "Critical structures in vortex dominated thermoacoustic systems", 73rd Annual Meeting of the APS Division of Fluid Dynamics, Virtual, 2020. Preview abstract
4. **Premchand, C.P.**, Reeja, K.V., Midhun, P.R., Raghunathan, M., Sujith, R. I., and Nair, V., "Optimal Passive Control of Thermoacoustic Instability: A Lagrangian Approach of Identifying Critical Structures.", 7th Prof. P J Paul Memorial Combustion Researchers Meet, IIT Bombay, India, February 14-15, 2020 (Poster presentation).
5. **Premchand, C.P.**, Reeja, K.V., Midhun, P.R., Raghunathan, M., Sujith, R. I., and Nair, V., "Identifying critical regions of sound production in the flow through a square duct containing two circular orifice plates", 12th Conference on Nonlinear Systems and Dynamics, IIT Kanpur, December 12-15, 2019.
6. Nair, V., **Premchand, C.P.**, Reeja, K.V., Midhun, P.R., Raghunathan, M., and Sujith, R. I., "Lagrangian analysis of intermittent sound sources in a flow-through square duct containing two circular orifice plates", 72nd Annual Meeting of the APS Division of Fluid Dynamics, Seattle (WA), USA, Volume 64, Number 13, November 23-26, 2019. Preview abstract

Conference publications - in-press and under preparation

1. **Premchand, C.P.**, Godse, S., Kolwyck, J., Alexander, L., Davenport, J., Acharya, R., and Palies, P., "Fully Premixed Hydrogen/air Swirl Flames Shapes and Transient Processes" ASME Turbo expo 2025, Memphis, Tennessee, USA. Paper No. GT2025-152560, June 16–20, 2025. (Accepted).

Patents - granted

1. **Premchand, C. P.**, Nair, V., Sujith, R. I., George, N. B., Raghunathan, M., and Unni, V. R., "System and method for optimizing passive control strategies of oscillatory instabilities in turbulent systems using finite-time Lyapunov exponents", Patent No: India: IN201941022545, USA: US11378488B2