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*

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) **Apr 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"

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

In my thesis, 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* [4]). 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* [1] 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* [3] 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* [1]). 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* [4] 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."
   Experiments by **Premchand, C.P.** in UTSI;
   Measurements: Flame dynamics using high speed camera, Schlieron 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;
   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. "Forcing experiments in double orifice configuration (aeroacoustic system) using loudspeaker"
   Designed by **Premchand C.P.** during Ph.D. tenure;
   Experiments by Ashutosh Singh and **Premchand, C.P.** in IIT-B;
   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

Referees

1. **Prof. Vineeth Nair**, 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 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**, 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**, Department of Mechanical, Aerospace, & Biomedical Engineering (MABE), University of Tennessee Space Institute, Tullahoma, Tennesse - 37388. 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 2021 Student Advisory Committee Travel Award (SACTA) from ASME-IGTI.
- 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.
- 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.

List of publications

Peer-Reviewed Journal publications - published

1. 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.
2. 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
3. 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
4. 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

5. Palies, Paul, and Premchand, C.P., "Hydrogen-air lean premixed turbulent highly swirled flames demonstration" (Submitted to Scientific Reports - Nature)
6. Premchand, C.P., and Palies, Paul, "Measurements of transient sequences for fully premixed hydrogen/air swirling flame" (Manuscript under preparation).
7. Premchand, C.P., and Palies, Paul, "Impact of bluff-body diameter on flame stability in fully premixed hydrogen/air swirling flames" (Manuscript under preparation).
8. Singh, A., Premchand, C.P., and Nair, V., "Effectiveness of active and passive control in flow past the cavity flows" (Manuscript under preparation).
9. Singh, A., Premchand, C.P., and Nair, V., "Experimental investigation of combustion instability in trapped vortex combustors" (Manuscript under preparation).
10. Thakare, P., Premchand, C.P., Sinha, K., and Nair, V., "Lagrangian analysis of high intensity shock-turbulence interaction" (Manuscript under preparation).
11. Premchand, C.P., and Nair, V., "A deep learning architecture for identifying the precursors to the onset of oscillatory instability" (Manuscript under preparation).

Peer-Reviewed conference publications - published

12. 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, June 24-June 28, 2024, London, United Kingdom GT2024-129264
13. 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: GT2020-14929, September 21–22, 2020. https://doi.org/10.1115/GT2020-16073
14. 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

15. 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.
16. 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

17. 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.
18. 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

19. 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.

Patents - granted

20. 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