Aravinth Sadagopan

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Developing data-driven/theoretical reduced-order models (ROMs) for complex fluid flows. Collaborated with experimental groups on multi-physics problems focusing on computational model validation and flow field analysis. Experience in turbomachinery aerodynamics, high-speed flows, and computational aeroelasticity.

Education

The Pennsylvania State University — University Park, PA

Doctor of Philosophy - Aerospace Engineering; GPA: 4/4 — *July 2019 - Present*

Thesis: *Fluid-Thermal-Structural interaction of a Cone-Slice-Ramp in High-Speed Flows*

The Pennsylvania State University — University Park, PA

Master of Science - Aerospace Engineering; GPA: 3.93/4 — *Aug 2016 - May 2019*

Thesis: *A Design Strategy for a 6:1 Supersonic Mixed-Flow Compressor Stage and its Viscous Flow-based Performance Assessment*

Amrita Vishwa Vidyapeetham — Coimbatore, India

Bachelor of Technology - Aerospace Engineering; GPA: 8.89/10 — *Aug 2012- May 2016*

Honors and Awards

Distinguished Master's Thesis Award (2019)

ASME International Gas Turbine Institute (IGTI) Student Scholarship (2017)

Research experience

The Pennsylvania State University — University Park, PA

Aerospace multi-physics and unconventional systems lab, PI: Dr. Daning Huang — *Graduate Student*

Computational Aeroacoustic Analysis of Jet Nozzle Flows — *Jan 2024 - present*

- Collaborating with Dr. Philip Morris (PSU) on the FAA ASCENT project to develop an efficient computational coarse LES-based framework (low-fidelity) to predict noise during landing and take-off of supersonic jets.

Data-Driven Input-Output Analysis of Fluid Flows with Quasi-Periodic Behavior — *Jan 2022 - present*

- Establishing the causal mechanism of a fluid system from data leveraging information about the governing equation. Building effective reduced-order models (ROM) combining dimension reduction and operator learning.
- Employed bi-spectral methods to characterize energy transfer on high-speed cavity flows (a quasi-periodic system).

ROM for Fluid-Thermal-Structural Interaction of Cone-Slice-Ramp (CSR) — *Dec 2024 - Present*

- Proposed a ROM-based FTSI framework to evaluate CSR-type geometries for a range of ramp angles at the low-Reynolds number inflow condition.
- Developing a fluid ROM based on composite analytical method and deep networks. Validated the thermo-structural module based on shell-finite element and modal solver.

Characterization of compressible shear layers of Cone-Slice-Ramp — *Jan 2022- Jan2024*

- Collaborated with Sandia National Laboratories (SNL) to investigate the compressible shear layer of cone-slice-ramp using LES. Flow features include shockwave/boundary layer interaction, low-frequency oscillation, shear layer flapping, and streamwise streaks and vortices. HPC resource: PSU ICDS Roar.
- Developed a local and biglobal stability analysis framework to extract modal and non-modal amplification mechanisms of compressible fluid flows using finite difference and spectral methods (Direct and Iterative solvers). Parallel version: SLEPc.

Numerical Investigation of FTSI on a Cone-Slice-Ramp in Hypersonic Flows — *Jan 2020- May 2022*

- Lead the joint experimental/computational collaborative effort with SNL and USAFA to investigate the FTSI behavior of CSR that emulates the control surface of a flight vehicle.
- Validated the high-fidelity FTSI computational framework comprising implicit LES, and FEM/Rayleigh-Ritz models. Discovered the interaction mechanism of this multi-physics problem. HPC resource: PSU ICDS Roar.

The Pennsylvania State University — University Park, PA

Turbomachinery Aero-Heat Transfer Lab, PI: Dr. Cengiz Camci — *Graduate Student*

Numerical Modeling of an HP Turbine Stage for Tip Leakage Flow Mitigation — *Aug 2018 - May 2019*

- Validated the computational model of a high-pressure (HP) Turbine stage at PSU-AFTRF experimental facility with RANS-based CFD using STAR-CCM+. Characterized the aerothermal losses due to tip leakage, and secondary flows in the blade passage to perform tip-design studies.
- Compared the effectiveness of various turbomachinery simulation techniques: mixing plane, sliding mesh, and harmonic balance method.

Design analysis of a 6:1 supersonic mixed-flow compressor (MFC): Master's Thesis — *Jan 2017 - July 2018*

- Proposed a single-stage high-pressure ratio compressor using first-order principles to address the surging demand in the small aircraft engine segment (1-10 kg/s).
- Optimized the design, validated and examined the flow physics with RANS-baed CFD using STAR-CCM+. A design point pressure ratio of 5.83 with 75.5% efficiency at 3.5Kg/s was achieved within 0.4m frontal diameter (*higher performance than existing MFCs in the open literature*).

Peer reviewed publications

1. **Sadagopan, A.**, Huang, D., "Reduced-order modeling for Fluid-Thermal-Structural interaction of Cone-Slice-Ramp in high-speed flows", *in progress.*
2. **Sadagopan, A.**, Huang, D., Pandey, A., Casper, K., DeChant, L., "Compressible shear layer dynamics of a cone-slice-ramp in high-speed flows", *in progress.*
3. **Sadagopan, A.**, Huang, D., Jirasek, A., Seidel, J., Pandey, A., Casper, K., " Hypersonic Fluid–Thermal–Structural Interaction of Cone–Slice–Ramp: Computations with Experimental Validation," AIAA Journal, 2023. DOI:10.2514/1.J062326
4. Huang, D., **Sadagopan, A.**, Duzel, U., Hanquist, K., "Study of Fluid-Thermal-Structural Interaction in High-Temperature High-Speed Flow using Multi-Fidelity Multi-Variate Surrogates", Journal of Fluids and Structures, 2022. DOI:10.1016/j.jfluidstructs.2022.103682
5. **Sadagopan, A.**, Camci, C., "A design strategy for a 6:1 supersonic mixed flow compressor", Aerospace Science and Technology, Elsevier, 2019. DOI:10.1016/j.ast.2019.02.026
6. **Sadagopan, A.**, Camci, C., "Viscous flow and performance issues in a 6:1 supersonic mixed-flow compressor with a tandem diffuser", Aerospace Science and Technology, Elsevier, 2019. DOI:10.1016/j.ast.2019.02.027.

Invited talks

1. **Sadagopan, A.**, "Fluid-Thermal-Structural Interaction of Cone-Slice-Ramp in High-Speed Flows," Lockheed Martin Advanced Topics in Structural Dynamics Seminar Series, May 8, 2024.
2. **Sadagopan, A.**, "Physical mechanism of shear layer oscillation on cone-slice-ramp in hypersonic flows," Penn State Aerospace Seminar Series, Feb 8, 2024.

conference proceedings

1. **Sadagopan, A.**, and Huang, D., "Reduced-Order Modeling for Fluid-Thermal-Structural Interaction of Cone-Slice-Ramp in High-Speed Flows," AIAA SciTech, Orlando, FL 2024.DOI:10.2514/6.2024-1050
2. **Sadagopan, A.**, and Huang, D., "Data-driven approach for input-output analysis of quasi-periodic systems," APS Division of Fluid Dynamics, 2023.
3. **Sadagopan, A.**, and Huang, D., "Modal analysis of a shear layer in high-supersonic cavity flows using data-driven and operator-based resolvent analysis," APS Division of Fluid Dynamics, 2022.
4. **Sadagopan, A.**, Huang, D., Jirasek, A., Seidel, J., Pandey, A., Casper, K., 'An experimental and computational correlation study for fluid-thermal-structural interaction of a control surface in hypersonic flow', AIAA SciTech 2022 Forum. DOI:10.2514/6.2022-0291
5. **Sadagopan, A.**, Huang, D., Xu, H., Yang, X., 'Numerical investigation of fluid-thermal-structural interaction for a control surface in hypersonic flow', AIAA SciTech 2021 Forum.DOI:10.2514/6.2021-0911
6. **Sadagopan, A.**, Huang, D., Duzel, U., Martin, LE., Hanquist, K., 'Assessment of high-temperature effects on hypersonic aerothermoelastic analysis using multi-fidelity multi-variate surrogates', AIAA SciTech 2021 Forum. DOI:10.2514/6.2021-1610
7. **Sadagopan, A.**, Huang, D., Hanquist, K., 'Impact of high-temperature effects on the aerothermoelastic behavior of composite skin panels in hypersonic flow', AIAA SciTech 2020 Forum. DOI:10.2514/6.2020-0937

Teaching experience

Teaching Assistant at the Dept. of Aerospace Engineering, The Pennsylvania State University

Duties included grading assignments, designing project questions, conducting office hours, and class recitations.

Courses: Aerodynamics I: Incompressible flow, Aerodynamics Lab and Aerospace analysis (undergraduate level) and Foundation of Fluid Mechanics (graduate level)

Coursework Projects

Large Eddy Simulation (LES) of Incompressible Decaying Isotropic Turbulence

Simulated isotropic decaying turbulence to compare Smagorinsky and Dynamic Smagorinsky models with DNS data in FORTRAN.

Two-dimensional Transonic Cascade Wind Tunnel Passage Flow Periodicity Study

Validated an axial turbine blade cascade using RANS-based computations in STAR-CCM+. Conducted a tailboard angle variation study to minimize the deviation of C_p values across the cascade airfoils.

Professional membership and academic services

American Society of Mechanical Engineers (ASME)

American Institute of Aeronautics and Astronautics (AIAA)

American Physics Society (APS)

Journal reviewer (>1): Aerospace Science and Technology, Journal of Fluids Engineering, Journal of Propulsion and Power, International Journal of Turbomachinery, Propulsion and Power, AIAA SciTech conference, AIAA Journal.

Skills Summary

- **Programming**: C, Fortran, Bash (Linux), MPI, PETSc, SLEPc
- **Packages**: STAR-CCM+, ABAQUS, Pointwise, ICEM, ANSYS Fluent, CharLES
- **Tools**: Matlab, Python (Pytorch, TensorFlow), Mathematica

Internship

Turbomachinery Lab, Bharat Heavy Electricals Limited (BHEL) Hyderabad, India

Summer 2015

Generated a turbine cascade using 'Pritchard' parameters for the given boundary conditions. Estimated pressure coefficient, Mach no. and lift distribution using vortex panel method for comparison against higher-fidelity RANS based computations.

References

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