ME Seminar

Computation and analytical prediction of unsteady combustion phenomena in gas turbines operated on sustainable fuels

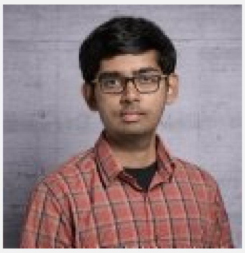
Dr. Harish S. Gopalakrishnan, Postdoctoral Fellow, Zurich University of Applied Sciences, Switzerland

ABSTRACT

Power generation for aircraft and land-based applications with fossil fuel combustion is a dominant contributor to carbon di-oxide emissions, causing global warming and climate change. Increased CO2 concentrations in the atmosphere has resulted in loss of biodiversity, increased risk of natural disasters and unpredictable weather patterns. However, even in projected scenarios for net zero emissions by 2050, combustion will continue to satisfy a substantial fraction of the total energy demand due to its use in energy intensive industries and transportation sectors. Therefore, it is important to transition towards combustion with carbon-neutral fuels: hydrogen and ammonia being two good candidates. This talk will focus on a crucial operability problem that severely affects the performance and life of a combustion system - combustion instability. Combustion instability is caused due to the interactions between acoustic waves and the flow-flame dynamics. Acoustic waves modulate the flow processes, flame kinematics and reaction kinetics resulting in an unsteady flame. Unsteady flames, in turn, act as sources of sound resulting in a coupled feedback between the two processes. This coupled feedback loop is governed by a variety of multi-physics interactions and is, generally, complex to predict. I will focus on three canonical combustion systems: a reheat combustor featuring an autoignition-stabilized hydrogen flame commonly seen in sequential combustion systems for land-based power generation, a slit□stabilized combustor featuring an anchored premixed hydrogen and ammonia-hydrogen flame commonly seen in aviation gas turbines, and a propagating hydrogen flame often observed in micro- and meso-scale combustion systems. The rich physics involved in flame-acoustic coupling and the spectrum of different flame response mechanisms at play will be elucidated using high-fidelity numerical computations. Finally, I will conclude the talk with an overview of analytical and reduced-order modeling tools developed to enable efficient prediction of instabilities in these configurations.

ABOUT THE SPEAKER

I completed my Bachelor’s degree (2016) in Aerospace Engineering from Amrita School of Engineering, Coimbatore followed by a Master’s degree (2018) in Aerospace Engineering from the Indian Institute of Science, Bangalore. I then worked for a year in the industry (Rolls-Royce India) before pursuing my PhD (2022) in combustion instability from the Norwegian University of Science and Technology, Trondheim, Norway with Prof. Jonas Moeck. I am currently employed as a Postdoctoral fellow at the Zurich University of Applied Sciences, Switzerland. My research interests are in combustion, acoustics, multi-phase flow combustion, hydrodynamic stability and pollutant emissions. My expertise is on CFD of compressible reactive flows, reduced-order modeling of combustion and acoustic phenomena and modeling of pollutant emissions from gas turbine engines.



28 November 2025, 4:00 PM, Online (MS Teams)