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Trapped Vortex Combustion: Insights from Laser Diagnostics & Numerical Simulations

Abstract

Syngas consisting mainly of a mixture of carbon monoxide, hydrogen and other diluents, is an important fuel for power generation applications, since it can be obtained from both biomass and coal gasification. One of the challenges arises from the very low calorific value of the syngas thus obtained. Clean coal technologies require stable and efficient operation of syngas-fired gas turbines with low emissions. Trapped vortex combustion (TVC) is a relatively new gas turbine combustor concept which shows tremendous potential in achieving stable combustion under wide operating conditions with low emissions, especially with low calorific value fuels. This talk will summarize a series of investigations conducted over several years in an optically-accessible trapped vortex combustor facility. Insights obtained on the combustion of syngas in the TVC facility using in-situ laser diagnostic techniques and numerical modeling will be presented. Specifically, in-situ measurements of mixture fraction, OH radical concentration and velocity in a single cavity TVC, using Planar Laser-induced Fluorescence (PLIF) and Particle Image Velocimetry (PIV) are used to identify important parameters dictating stability and emissions. These studies have shown the fuel-air momentum flux ratio to be an important governing parameter in addition to

identifying various flame stabilization regimes. Numerical simulations using Unsteady Reynolds-averaged Navier-Stokes (URANS) and Large Eddy Simulation (LES) approaches have also been conducted to complement the experimental measurements. The computations have been used to evaluate several innovative ideas to improve stability. The efficacy of one such innovation involving use of a flow guide vane has been confirmed in experiments. Overall, the talk will highlight how the in-situ experimental data coupled with insight from simulations confirm the advantages of adapting the TVC concept for gas turbines, and provide guidelines for stable and efficient operation of the combustor with syngas fuel. The talk will conclude by highlighting future directions and challenges, especially with trapped vortex combustion at elevated pressures.

Short Bio

R. V. Ravikrishna obtained his M.S. degree from the University of Alabama, USA, and PhD from Purdue University, USA. He joined the faculty of the Indian Institute of Science, Bangalore, India, in 1999 and is currently the Pratt & Whitney Chair Professor in the Department of Mechanical Engineering. He also heads the National Centre for Combustion Research & Development (NCCRD) at IISc, Bangalore. Broadly, his research involves Combustion and Flow Diagnostics using Laser-based Techniques with applications in IC Engines and Gas Turbines. His current focus is on catalytic and MILD combustion, development of compact combustors based on the trapped vortex concept and atomization of biofuels. He has published more than 180 papers in peer-reviewed journals and conferences and holds 7 patents. His current and past PhD students number 23, of which 7 are currently faculty members in the various Indian Institutes of Technology (IITs). He is a member of the Executive Committee of the Combustion Institute (Indian Section), and is also an International Board Member of the ILASS-Asia. He was the Organizing Chair of the 18th ILASS-Asia Conference, 2016, and an Advisory Board Member for COMODIA 2017, Japan.