Singapore Section of the Combustion Institute

SSCI | Young Combustion Researchers Webinar

Trapped vortex combustors: Flow structures, flame stabilization and combustion performance

Dr. Yuxi Guo

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Time: November 30th, 2026, 17:00 Singapore

Host: Dr. Shangpeng Li (National University of Singapore)

Zoom meeting: https://nus-sg.zoom.us/j/89300464091

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ABSTRACT

Trapped vortex combustors (TVCs) provide an approach to stabilizing combustion over a wide operating range by sustaining recirculating flows within cavities. The trapped vortices retain hot combustion products and support continuous ignition of incoming reactants, offering opportunities for compact combustor designs with high flow velocities. However, maintaining a stable cavity flame while achieving effective mixing and efficient combustion in the main stream remains a central design challenge. This talk presents an overview of TVC development and the physical mechanisms governing their flow and combustion behaviour, drawing on experimental and numerical studies, with a swirling-flow configuration as a case study. Particle image velocimetry, high-speed flame imaging and combustion performance measurements are used to examine the links between vortex structures, ignition, flame propagation and lean blowout. The results reveal how interactions between cavity recirculation and the main flow produce distinct flow regimes and three-dimensional transport pathways, which influence flame-kernel stabilization and flame spreading into the main combustion zone. The effects of inlet conditions, combustor geometry and pilot-to-main fuel distribution on combustion efficiency, emissions and outlet temperature distribution are also discussed. The swirling-flow configuration illustrates how a stable cavity pilot can be combined with enhanced mixing in the main zone to support efficient combustion. Finally, the talk considers how these findings inform TVC design, with particular attention to balancing flame stability, mixing, pressure loss and combustion performance for advanced gas turbine applications.

ABOUT THE SPEAKER



Dr. Yuxi Guo is a Research Fellow at Nanyang Technological University (NTU), working with Prof. Fei Duan on the HYCOMBS project. He received his Ph.D. in Engineering Thermophysics from Nanjing University of Aeronautics and Astronautics (NUAA) in 2024, under the supervision of Prof. Xiaomin He. His research focuses on turbulent spray combustion, flame stabilization and advanced combustor design for gas turbine combustor, with particular interest in trapped vortex combustion and operation over a wide range of conditions. His doctoral research combined experiments and numerical simulations to investigate flow structures, ignition and lean blowout, flame propagation, and combustion and emission performance in trapped vortex combustors. A central theme was the integration of cavity-based flame stabilization with swirling main flows to improve fuel–air mixing and combustion performance. His work spans combustor concept development, prototype design and performance evaluation. He uses particle image velocimetry, high-speed imaging and exhaust gas analysis, complemented by computational fluid dynamics, to relate flow and flame behaviour to combustor performance. He was a visiting doctoral researcher at NTU from 2023 to 2024, supported by the China Scholarship Council. He has published in Aerospace Science and Technology, Energy and Applied Thermal Engineering etc.