

**Proceedings of ASME Turbo
Expo 2025: Turbomachinery
Technical Conference and
Exposition**

(GT2025)

Volume 3A

**June 16-20, 2025
Memphis, Tennessee**

Conference Sponsor
International Gas
Turbine Institute

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

© 2025, The American Society of Mechanical Engineers, 290 W. Mount Pleasant Avenue, Suite 1400, Bldg. 4, Livingston, NJ 07039, USA (www.asme.org)

All rights reserved. “ASME” and the above ASME symbols are registered trademarks of the American Society of Mechanical Engineers. No part of this document may be copied, modified, distributed, published, displayed, or otherwise reproduced in any form or by any means, electronic, digital, or mechanical, now known or hereafter invented, without the express written permission of ASME. No works derived from this document or any content therein may be created without the express written permission of ASME. Using this document or any content therein to train, create, or improve any artificial intelligence and/or machine learning platform, system, application, model, or algorithm is strictly prohibited.

INFORMATION CONTAINED IN THIS WORK HAS BEEN OBTAINED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS FROM SOURCES BELIEVED TO BE RELIABLE. HOWEVER, NEITHER ASME NOR ITS AUTHORS OR EDITORS GUARANTEE THE ACCURACY OR COMPLETENESS OF ANY INFORMATION PUBLISHED IN THIS WORK. NEITHER ASME NOR ITS AUTHORS AND EDITORS SHALL BE RESPONSIBLE FOR ANY ERRORS, OMISSIONS, OR DAMAGES ARISING OUT OF THE USE OF THIS INFORMATION. THE WORK IS PUBLISHED WITH THE UNDERSTANDING THAT ASME AND ITS AUTHORS AND EDITORS ARE SUPPLYING INFORMATION BUT ARE NOT ATTEMPTING TO RENDER ENGINEERING OR OTHER PROFESSIONAL SERVICES. IF SUCH ENGINEERING OR PROFESSIONAL SERVICES ARE REQUIRED, THE ASSISTANCE OF AN APPROPRIATE PROFESSIONAL SHOULD BE SOUGHT.

ASME shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B7.1.3). Statement from the Bylaws.

For authorization to photocopy material for internal or personal use under those circumstances not falling within the fair use provisions of the Copyright Act, contact the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923, tel:978-750-8400, www.copyright.com.

Requests for special permission or bulk reproduction should be addressed to the ASME Publishing Department, or submitted online at: <https://www.asme.org/publications-submissions/journals/information-for-authors/journalguidelines/rights-and-permissions>

ISBN: 978-0-7918-8878-0

TABLE OF CONTENTS

Investigation of Combustion Characteristics of Hydrogen Lifted Flames in a Small Hydrogen Combustion Chamber.....	1
<i>A. K. M. Nazrul Islam, Kazunori Ichieda, Takashi Sakurai</i>	
GPU Accelerated Large Eddy Simulations of Combustion Instabilities in Industrial Gas Turbines Under EGR Conditions.....	12
<i>Islam Kabil, Chao Xu, Lee Shunn, Jonathan Wang, Yonduck Sung, Daniel Johnson, Chris Steele</i>	
Azimuthal Instabilities Arising in an Annular Combustor Equipped With Pure Hydrogen Injection Units	26
<i>Nicolas Vaysse, Daniel Durox, Ronan Vicquelin, Sebastien Candel, Antoine Renaud</i>	
The Influence of Turbulence Intensity on NO _x Emission and Flame Topology in Ammonia/Air Premixed Combustion	38
<i>Inyeong Gu, Dong-hyuk Shin</i>	
Comprehensive Modeling of the Cause-And-Effect Chain in Aero-Engine Combustor Simulations: From Primary Breakup to Soot Formation	48
<i>Philipp Koob, Hendrik Nicolai, Andreas Lindenthal, Frederic Aaron Witkind Hirth, Niklas Burkle, Thomas Soworka, Ruud Eggels, Carsten Clemen, Rainer Koch, Thomas Behrendt, Michael Schroll, Christian Hasse</i>	
Surface Roughness Effects on the Operability and Performance of a Hydrogen Jet Burner	60
<i>Robin Vivoli, Daniel Pugh, Burak Goktepe, Sally Hewlett, Anthony Giles, Richard Marsh, Steven Morris, Philip Bowen</i>	
On the Generation of Entropy Waves in the Dilution Zone of a Rich-Quench-Lean Combustion Chamber	72
<i>Thuy An Do, Angel Brito Gadeschi, Gregoire Varillon, Agnes Jocher</i>	
Large Eddy Simulation of the PRECCINSTA Combustor Using a Native GPU Solver	84
<i>Yu Xia, Ashwini Dalvi, Florian Menter, David Flad, Andreas Hueppe</i>	
Experimental Investigation of a Non-Premixed H ₂ /Air Swirled Flame at Elevated Pressure Using Optical Diagnostics	97
<i>Yannick Touzeau, Sylvain Petit, Cornelia Irimiea, Benjamin Blaisot, Guillaume Pilla, Ajmal Khan Mohamed</i>	
Experimental Combustor Research in Sustainable Aviation Fuel at Rolls-Royce: Strategy, Achievements, and Outlook	109
<i>Denise Ahrens, Gregor Gebel, Rohit Singh Pathania, Chris Armit, Katja Lohnert, Carsten Clemen</i>	
Hydrogen Micro-Mix Fuel Injection: Design & Evaluation.....	122
<i>Mark Brend, Yanling Li, Murthy Ravikanti</i>	
Investigation of Dual-Flame-Front Stabilization in Partially Premixed Hydrogen Flames Using Synchronized PIV/OH-PLIF	133
<i>Maxime Leroy, Clement Mirat, Antoine Renaud, Stefano Puggelli, Ronan Vicquelin</i>	

Design by Large-Eddy Simulations of a Rich Burn - Quick Mix - Lean Burn Lab-Scale Combustion Chamber Operating in High-Pressure Conditions.....	144
<i>Afaf Karrouk, Benjamin Quevreux, Clement Brunet, Stephane Richard, Gilles Cabot, Frederic Grisch</i>	
Performance and Emission Footprint of Decentralized H ₂ /NH ₃ Gas Turbines With On-Site Ammonia Decomposition and Exhaust Aftertreatment	154
<i>Christian Gossrau, Nils Hendrik Petersen, Laurenz May, Manfred Wirsum</i>	
Towards the Development of an NH ₃ -RRQL System Part 2: Effects of the Primary Combustion Zone Length and Secondary Stage Number of Holes on Stability and Emissions	169
<i>Cristian D. Avila Jimenez, Renee Cole, David R. Noble, Robert Steele, David Wu, Benjamin L. Emerson, Timothy C. Lieuwen</i>	
Characterization of Flashback and Flame-Holding in a Jet-in-Crossflow Mixing Configuration With Methane-Hydrogen Fuel Blends.....	178
<i>Pradeep Parajuli, Peter Strakey</i>	
Coherent Anti-Stokes Raman Spectroscopy Temperature Measurements in a Swirl-Stabilized Spray Combustor	190
<i>Nicholas Rock, Scott Stouffer, Tyler Hendershott, Edwin Corporan, Paul Wrzesinski</i>	
Experimental Investigation of Recursive Sequential Combustion: Early Experimental Demonstration, Emission Analysis, and CFD Insights.....	202
<i>Nina Paulitsch, Fabrice Giuliani, Andrea Hofer, Arno Fallast</i>	
Design of a Rich-Burn Hydrogen Micromix Injector for Investigating Entropy Waves	212
<i>Angel Brito Gadeschi, Thuy An Do, Agnes Jocher</i>	
LES of Hydrogen-Fuelled Combustion in the First Stage of the Ansaldo Energia GT36 Constant Pressure Sequential Combustion System.....	224
<i>Aldo Schioppa, Luis Tay-Wo-Chong, Andrea Ciani, Laurent Gicquel</i>	
Numerical Demonstration of NO Emissions Reduction by Steam Injection in the Aero Engine Combustor IAE V2500.....	236
<i>Marian Hiestermann, Matthias Haeringer, Marcel Desor, Korbinian Niebler, Lukas Berger</i>	
Thermo-Acoustic Instabilities and Shape Bifurcations of a Pilot-Only Spray Flame in a Staged Burner.....	246
<i>Quentin Buisson, Antoine Renaud, Laurent Zimmer, Guillaume J. J. Fournier, Abel Faure- Beaulieu, Yoann Mery, Sebastien Ducruix</i>	
Operability Study With Spatial Resolved Temperature and Water Molar Concentration Measurements of a New Pressurised Optical Modular Staged Combustor	258
<i>Anthony Giles, Lee Weller, Burak Goktepe, Oussama Chaib, Priyav Shah, Ben Williams, Andrew Crayford, Daniel Pugh, Simone Hochgreb</i>	
Simulations of a Swirl Stabilised Non-Premixed Hydrogen Flame With a Flamelet Generated Manifold Approach.....	269
<i>Ashley van Bruygom, Andrew Garmory, A. Duncan Walker</i>	
Experimental Characterization of Loss Mechanism During Probe-Based NVPM Measurements.....	279
<i>Lena Voigt, Thomas Behrendt, Bertram Janus</i>	

Investigation of Critical Operating Conditions for Hydrogen Flames Under Typical Gas Turbine Conditions	288
<i>Holger Ax, Oliver Lammel, Rainer Luckerath, Joshua Gray, Benjamin Witzel, Lutz Blatte, Berthold Kostlin</i>	
Development and Assessment of Dual-Fuel Capabilities in Next-Generation Aero-Engine Injectors for Hydrogen and Liquid Fuels	298
<i>Sofya Buro, Ruud Eggels, Hendrik Nicolai, Christian Hasse</i>	
An Extended Artificially Thickened Flame Model for Turbulent Hydrogen and Hydrogen-Enriched Flames With Intrinsic Instabilities Under Gas Turbine Relevant Conditions	310
<i>Vinzenz Schuh, Driss Kaddar, Antonia Bahr, Mathis Bode, Christian Hasse, Hendrik Nicolai</i>	
Review and Development of Natural Gas/Hydrogen Fuel Flexible Reduced Chemical Mechanism for High-Order Modeling of Gas Turbines Part II: NO _x Chemistry.....	321
<i>Miguel A. Valles Castro, Bret C. Windom</i>	
Impact of Change in Atomization on Lean Blow Out for Sustainable Aviation Fuels in Gas Turbine Combustors.....	339
<i>Debolina Dasgupta, Sibendu Som</i>	
Structure of High-Pressure Premixed Ammonia, Hydrogen, and Methane Flames With 100 kHz OH-PLIF Measurements	349
<i>Tristan T. Shahin, Alexander J. Hodge, Benjamin K. Murdock, Keaton C. Koenig, Ellouise K. Moehring, Rohan M. Gejji, Robert P. Lucht, Carson D. Slabaugh</i>	
The Control of Hydrogen-Air Ignition Dynamics to Prevent Flashback.....	361
<i>Matteo Amerighi, Giada Senatori, Antonio Andreini</i>	
Experimental Investigation of Strut Injectors for Hydrogen/Air Combustion at Atmospheric Pressure in Non-Reactive and Reactive Conditions	372
<i>Vincent Gope, Alexis Vandell, Benjamin Quevreux, Maxim Kuvshinov, Pradip Xavier, Gilles Cabot, Frederic Grisch</i>	
Raman Analysis for Gas Turbine Fuel Gas Characterization	382
<i>Daniele Possanzini, Maura Pasquotti</i>	
Effect of Film Cooling Hole Location on Flow Dynamics in a Rotating Detonation Combustor.....	390
<i>Shreyas Ramanagar Sridhara, Marc D. Polanka, Myles D. Bohon, Antonio Andreini</i>	
Reduced-Fidelity Detonation Model Using Multistate Approximation for Rotating Detonation Combustors.....	402
<i>Yusuf Keskinov, Oliver Gibson, Venkatramanan Raman</i>	
Fully Premixed Hydrogen-Air Swirl Flames Shapes and Transient Processes.....	410
<i>C. P. Premchand, Sagar Godse, Jonathan Kolwyck, Larry Alexander, Joel Davenport, Ragini Acharya, Paul Palies</i>	
Heterodyne Background-Oriented Schlieren for Diagnostics of Reactive Flows	425
<i>Sami Tasmany, Jakob Woisetschlager, Johannes Gurtler, Robert Kuschmierz, Jurgen Czarske</i>	
An Industry Approach of Aero-Engine Fuel Spray Nozzle Optimization for Thermoacoustics.....	434
<i>Claus Lahiri, Andre Fischer, Manuel Gonzalez-Flesca, Juan Carlos Roman Casado, Leo C. C. Mesquita, Mick Macquisten</i>	

Numerical Investigation of Premixed and Non-Premixed Hydrogen Flames Using Large-Eddy Simulations and Flamelet Models	442
<i>Antonio Masucci, Tiziano Ghisu, Andrea Giusti</i>	
The Impact of a Surrounding Co-Flow on the Thermoacoustic Stability of a Premixed CH ₄ /H ₂ Flame.....	455
<i>Qian Wang, Aksel Anestad, Nicholas Alexander Worth</i>	
Experimental Analysis of Operating Frequency Enhancement and Pressure Characteristics in a Pulsed Detonation Combustor	470
<i>Andrei Vlad Cojocea, Mihnea Gall, Ionut Porumbel, George Vrabie, Tudor Cuciuc, Daniel Eugeniu Crunteanu</i>	
A Study on Combustion Characteristics of Radial Inward Flow Porous Media Burners for Ammonia-Hydrogen Flames	487
<i>Guguloth Mahesh Nayak, Beni Cukurel, Joseph K. Lefkowitz</i>	
Effect of Exhaust Gas Recirculation on Combustion Efficiency in a Swirl-Stabilized Flame With Blends of Natural Gas and Hydrogen.....	502
<i>Javier Rodriguez Camacho, Christopher Birkbeck, Min Kyeong Yoon, Ana Victoria Kock, Sang Hee Won, Jacqueline O'Connor</i>	
Comparative Evaluation of Flamelet Generated Manifold and Finite Rate Combustion Model Results for Bluff Body Stabilized Pure Hydrogen Flame Using NTNU Atmospheric Rig Test Data	515
<i>Vijay Narayan, Sourabh Shrivastava, Naseem Ansari, Pravin Nakod</i>	
A FlameSheet(TM) Combustion System With Cracked Ammonia As a Fuel	530
<i>Nicolas Demougeot, Lucky Tran, Fred Hernandez, Ramesh Keshava-Bhattu, Bryan Kalb, Matthew Yaquinto, Ryan Piersa</i>	
Characterization of a Fluidically-Variable Swirl Burner: Effects of the Imprinted Swirl on Flame Shapes and Emissions for Hydrogen-Methane Blends.....	544
<i>Mattias E. G. Eck, Philipp zur Nedden, Jakob G. R. von Saldern, Alessandro Orchini, Christian Oliver Paschereit</i>	
Characteristic Time Scale Modelling of Gas Turbine Combustor Ignition Limits at Sub Idle Conditions	555
<i>Calum Hargreaves, Paul Denman, Dimitri Franz, Ian Mariah, Jon F. Carrotte, A. Duncan Walker</i>	
Co-Firing Hydrogen With Natural Gas for 9 MW Siemens Energy Dry Low Emissions Combustor: Part I - High Pressure Rig Test	567
<i>Kexin Liu, Suresh Sadasivuni, Jadeed Beita</i>	
Co-Firing Hydrogen With Natural Gas for 9 MW Siemens Energy Dry Low Emissions Combustor: Part II - Large Eddy Simulations	581
<i>Liam McManus, Nick Fogell, Kexin Liu, Suresh Sadasivuni, Jadeed Beita, Erik Munktell</i>	
Linear Stability Analysis of Transversal Thermoacoustic Modes in Reheat Combustors	595
<i>Simon Manuel Heinzmann, Harish Subramanian Gopalakrishnan, Birute Wood, Mirko Ruben Bothien</i>	
Modeling of Particulate Emissions From Conventional and Sustainable Jet Fuels in Aero Engine Combustors.....	609
<i>Daniel Lieder, Jan Going, Robert Schmitz, Jens Friedrichs, Federica Ferraro</i>	

Chemical Reactor Network Modeling of Ammonia Rich-Quench-Lean Combustion Using a Partially Stirred Reactor Approach.....	621
<i>Clinton Bedick, Wesley Boyette</i>	
Characterization of Heat Transfer in a Trapped-Vortex Combustor Designed for High-Temperature Material Testing.....	632
<i>Porter Richins, Caleb Clark, Madelyn Cassens, Stephen Lynch, Jacqueline O'Connor</i>	
Investigation of Flashback Limits and Detection Strategies for Jet-Stabilized Hydrogen Flames.....	646
<i>Philipp Maximilian zur Nedden, Oscar Luis Montagne, Christoph Peisdersky, Mattias Ettore Giulio Eck, Finn Simon Luckoff, Alessandro Orchini, Christian Oliver Paschereit</i>	
Coupling Micro-Mixing Combustion With a Pre-Reactor Operating Under Ultra-Rich Conditions for Low-NO _x Combustion of Hydrocarbons.....	657
<i>Xavier Bellavance, Alexandre Landry-Blais, Jean-Sebastien Plante, Mathieu Picard</i>	
Numerical Study and Validation of the Near-Nozzle Spray Behavior of a Non-Proprietary Pressure-Swirl Atomizer for Aviation Applications.....	672
<i>Austin Han, Ashwini Karmarkar, Brandon A. Sforzo, Christopher F. Powell, Lorenzo Nocivelli</i>	
Numerical Investigation of Vertical Spacing Effects on Flame Behaviour and NO _x Emissions in Hydrogen Micromix Injector Pairs.....	683
<i>Guillermo Gonzalez Lopez, Gaurav Singh, Vishal Sethi, David Cadrecha Robles, Pedro Romero Vega</i>	

Author Index