

**Proceedings of  
ASME Turbo Expo 2021: Turbomachinery  
Technical Conference and Exposition**

**Volume 3A**

**June 7-11, 2021  
Virtual, Online**

**Conference Sponsor**  
International Gas Turbine Institute

**THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS**

Two Park Avenue \* New York, N.Y. 10016

© 2021, The American Society of Mechanical Engineers, 2 Park Avenue, New York, NY 10016, USA  
(www.asme.org)

All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of the publisher.

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: 978-0-7918-8494-2

# CONTENTS

## Proceedings of ASME Turbo Expo 2021: Turbomachinery Technical Conference and Exposition

### Combustion, Fuels, and Emissions

<b>GT2021-58341</b> .....	<b>V03AT04A001</b>
Gradient-Free Optimization in Thermoacoustics: Application to A Low-Order Model <i>Johann Moritz Reumschüssel, Jakob G. R. von Saldern, Yiqing Li, Christian Oliver Paschereit, and Alessandro Orchini</i>	
<b>GT2021-58352</b> .....	<b>V03AT04A002</b>
Confidence in Flame Impulse Response Estimation From LES With Uncertain Thermal Boundary Conditions <i>Sagar Kulkarni, Shuai Guo, Camilo F. Silva, and Wolfgang Polifke</i>	
<b>GT2021-58358</b> .....	<b>V03AT04A003</b>
Impact of a Centrebody on the Unsteady Flow Dynamics of A Swirl Nozzle: Intermittency of PVC Oscillations <i>Saarthak Gupta, Santosh Hemchandra, Masayasu Shimura, Santosh Shanbhogue, and Ahmed Ghoniem</i>	
<b>GT2021-58456</b> .....	<b>V03AT04A004</b>
Amplitude-Dependent Damping and Driving Rates of High-Frequency Thermoacoustic Oscillations in a Lab-Scale Lean-Premixed Gas Turbine Combustor <i>Thomas Hofmeister and Thomas Sattelmayer</i>	
<b>GT2021-58476</b> .....	<b>V03AT04A005</b>
Toward Machine Learned Highly Reduced Kinetic Models for Methane/Air Combustion <i>Mark Kelly, Stephen Dooley, and Gilles Bourque</i>	
<b>GT2021-58535</b> .....	<b>V03AT04A006</b>
Influence of Hole-to-Hole Interaction on the Acoustic Behavior of Multi-Orifice Perforated Plates <i>Alireza Javarehshkian, Alexis Dancelme, Hongyu Chen, and Thomas Sattelmayer</i>	
<b>GT2021-58602</b> .....	<b>V03AT04A007</b>
Design and Validation of a Novel Test-Rig for RQL Flame Dynamics Studies <i>Martin March, Julian Renner, Christoph Hirsch, and Thomas Sattelmayer</i>	
<b>GT2021-58622</b> .....	<b>V03AT04A008</b>
Synergistic Effect of Soot Formation in Ethylene/Propane Co-Flow Diffusion Flames at Elevated Pressures <i>Dongsheng Zheng, Xin Hui, Xin Xue, and Weitao Liu</i>	
<b>GT2021-58650</b> .....	<b>V03AT04A009</b>
Hydrogen Blending Into Ansaldo Energia AE94.3A Gas Turbine: High Pressure Tests, Field Experience and Modelling Considerations <i>A. Ciani, L. Tay-Wo-Chong, A. Amato, E. Bertolotto, and G. Spataro</i>	
<b>GT2021-58653</b> .....	<b>V03AT04A010</b>
Experimental Investigation of the Confinement Effects in Radial-Radial Swirlers <i>Firat Kıyıcı and Mustafa Perçin</i>	
<b>GT2021-58660</b> .....	<b>V03AT04A011</b>
The Development Problems of Two-Fuel Burner for the Gas Turbine Combustion Chamber <i>A. Yu Vasilyev, O. G. Chelebyan, A. I. Maiorova, A. N. Tarasenko, D. S. Tarasov, and V. M. Zakharov</i>	
<b>GT2021-58675</b> .....	<b>V03AT04A012</b>
Experimental Characterization of the Combustion in Fuel Flexible Humid Power Cycles <i>Simeon Dybe, Felix Güthe, Michael Bartlett, Panagiotis Stathopoulos, and Christian Oliver Paschereit</i>	

<b>GT2021-58691</b> .....	<b>V03AT04A013</b>
On the Effect of Noise Induced Dynamics on Linear Growth Rates of Oscillations in an Electroacoustic Rijke Tube Simulator <i>Neha Vishnoi, Pankaj Wahi, Aditya Saurabh, and Lipika Kabiraj</i>	
<b>GT2021-58699</b> .....	<b>V03AT04A014</b>
Spark Ignition of SPP Injector Under Sub-Atmospheric Conditions <i>Qianpeng Zhao, Yong Mu, Jinhu Yang, Yulan Wang, and Gang Xu</i>	
<b>GT2021-58706</b> .....	<b>V03AT04A015</b>
Experimental Investigation of Dual-Swirl Spray Flame in a Fuel Staged Optical Model Combustor With Laser Diagnostics <i>Siheng Yang, Jianchen Wang, Zhichao Wang, Meng Han, Yuzhen Lin, and Yexin Wang</i>	
<b>GT2021-58770</b> .....	<b>V03AT04A016</b>
A Computationally Efficient Method That Predicts Light-Around for Both Gas- and Liquid-Fueled Combustion <i>Ellen Meeks, Chitralkumar V. Naik, Giuliana Litrico, and Samir Rida</i>	
<b>GT2021-58777</b> .....	<b>V03AT04A017</b>
Transient Thermoacoustic Responses of Methane/Hydrogen Flames in a Pressurized Annular Combustor <i>Byeonguk Ahn, Thomas Indlekofer, James Dawson, and Nicholas Worth</i>	
<b>GT2021-58794</b> .....	<b>V03AT04A018</b>
Impact of Hydrogen Addition on the Thermoacoustic Instability and Precessing Vortex Core Dynamics in a CH <sub>4</sub> /H <sub>2</sub> /air Technically Premixed Combustor <i>Anindya Datta, Saarthak Gupta, Santosh Hemchandra, Ianko Chtereve, and Isaac Boxx</i>	
<b>GT2021-58814</b> .....	<b>V03AT04A019</b>
A Kinematic Study of Individual Rotating Detonation Engine Waves Using K-means Algorithm <i>Taha Rezzag, Robert Burke, and Kareem Ahmed</i>	
<b>GT2021-58830</b> .....	<b>V03AT04A020</b>
Experimental Study on Lean Blowout Limits of Turbulent Premixed Hydrogen/Ammonia/Air Mixtures <i>Andreas Goldmann and Friedrich Dinkelacker</i>	
<b>GT2021-58832</b> .....	<b>V03AT04A021</b>
Modal Decomposition and Linear Modeling of Swirl Fluctuations in the Mixing Section of a Model Combustor Based on PIV Data <i>Jens Satria Müller, Finn Lückoff, Thomas Ludwig Kaiser, Christian Oliver Paschereit, and Kilian Oberleithner</i>	
<b>GT2021-58862</b> .....	<b>V03AT04A022</b>
Influence of Acoustically Excited Airflows on a Planar Airblast Prefilmer <i>Thomas Christou, Björn Stelzner, and Nikolaos Zarzalis</i>	
<b>GT2021-58896</b> .....	<b>V03AT04A023</b>
Analytical Formulation-Based Soot Modelling in Ethylene Laminar Jet Diffusion Flames <i>Amit Makhija and Krishna Sesha Giri</i>	
<b>GT2021-58903</b> .....	<b>V03AT04A024</b>
Delay Identification in Thermoacoustics <i>F. Gant, G. Ghirardo, A. Cuquel, and M. R. Bothien</i>	
<b>GT2021-58926</b> .....	<b>V03AT04A025</b>
Experimental and Numerical Investigation on the Effect of Pressure On Micromix Hydrogen Combustion <i>Daniel Kroniger, Atsushi Horikawa, Harald H.-W. Funke, Franziska Pfaeffle, Tsuyoshi Kishimoto, and Koichi Okada</i>	
<b>GT2021-58938</b> .....	<b>V03AT04A026</b>
Lean-Blow-Out Simulation of Natural Gas Fueled, Premixed Turbulent Jet Flame Arrays With LES and FGM-Modeling <i>Alexander Schwagerus, Peter Habisreuther, and Nikolaos Zarzalis</i>	

<b>GT2021-58947</b> .....	<b>V03AT04A027</b>
Low-Order Modeling of Can-Annular Combustors <i>Guillaume J. J. Fournier, Max Meindl, Camilo F. Silva, Giulio Ghirardo, Mirko R. Bothien, and Wolfgang Polifke</i>	
<b>GT2021-58961</b> .....	<b>V03AT04A028</b>
Combustor Wall Surface Temperature and Heat Flux Measurement Using a Fiber-Coupled Long Wave Infrared Hyperspectral Sensor <i>Aravind Chandh, Oleksandr Bibik, Subodh Adhikari, David Wu, Tim Lieuwen, Paul Hsu, Sukesh Roy, Ruth Sikorski, and Benjamin Emerson</i>	
<b>GT2021-58986</b> .....	<b>V03AT04A029</b>
Enhancing Fuel Flexibility in Solar's® Titan™ 250 Dry Low Emissions Combustion System <i>Michael Ramotowski and Donald Cramb</i>	
<b>GT2021-59009</b> .....	<b>V03AT04A030</b>
Optimization of Fuel Nozzle Diameter in a Novel Cross Flow Lean Direct Injection Burner <i>Kingshuk Chakraborty and S. R. Chakravarthy</i>	
<b>GT2021-59029</b> .....	<b>V03AT04A031</b>
A Design of Experiments Based Investigation of the Influence of Hot Cross-Flow Gas on a FLOX®-Based Single-Nozzle Liquid Burner <i>Saeed Izadi, Jan Zanger, Oliver Kislak, Benedict Enderle, Felix Grimm, Peter Kutne, Manfred Aigner, and Cedric Kraus</i>	
<b>GT2021-59053</b> .....	<b>V03AT04A032</b>
Ignition Delay Time Correlation of C1 – C5 Natural Gas Blends for Intermediate and High Temperature Regime <i>A. Abd El-Sabor Mohamed, Amrit Bikram Sahu, Snehasish Panigrahy, Gilles Bourque, and Henry Curran</i>	
<b>GT2021-59061</b> .....	<b>V03AT04A033</b>
Flow Fields, Emission and Stabilization in Premixed Centrally-Staged Swirl Flames With Different Air Split Ratios <i>Tong Su, Yuzhen Lin, Chi Zhang, and Xiao Han</i>	
<b>GT2021-59063</b> .....	<b>V03AT04A034</b>
Modelling of Turbulent Premixed CH <sub>4</sub> /H <sub>2</sub> /Air Flames Including the Influence of Stretch and Heat Losses <i>Halit Kutkan, Alberto Amato, Giovanni Campa, Giulio Ghirardo, Luis Tay Wo Chong, and Eirik Æsøy</i>	
<b>GT2021-59071</b> .....	<b>V03AT04A035</b>
NO <sub>x</sub> Emission Modelling for Lean Premixed Industrial Combustors With a Diffusion Pilot Burner <i>Johann Moritz Reumschüssel, Jakob G. R. von Saldern, Thomas Ludwig Kaiser, Thoralf Reichel, Jan Paul Beuth, Bernhard Čosić, Franklin Genin, Kilian Oberleithner, and Christian Oliver Paschereit</i>	
<b>GT2021-59074</b> .....	<b>V03AT04A036</b>
Center Body Burner for Sequential Combustion: Superior Performance at Lower Emissions <i>A. Ciani, J. P. Wood, M. Maurer, B. Bunkute, D. Pennell, S. Riazantsev, and G. Früchtel</i>	
<b>GT2021-59098</b> .....	<b>V03AT04A037</b>
Experimental Investigation of Fuel Staging Effect on Modal Dynamics of Thermoacoustic Azimuthal Instabilities in a Multi-Nozzle Can Combustor <i>J. Kim, W. Gillman, T. John, S. Adhikari, D. Wu, B. Emerson, V. Acharya, T. Lieuwen, M. Isono, and T. Saitoh</i>	
<b>GT2021-59100</b> .....	<b>V03AT04A038</b>
Dynamic Mesh Adaption for Scale-Resolving Reacting Flow Simulations <i>Yu Xia, Phil Stopford, Patrick Sharkey, and Ishan Verma</i>	
<b>GT2021-59113</b> .....	<b>V03AT04A039</b>
Relative Effects of Velocity- and Mixture-Coupling in a Thermoacoustically Unstable, Partially-Premixed Flame <i>Ashwini Karmarker, Jacqueline O'Connor, and Isaac Boxx</i>	

<b>GT2021-59117</b> .....	<b>V03AT04A040</b>
Describing the Mechanism of Instability Suppression Using a Central Pilot Flame With Coupled Experiments and Simulations	
<i>Jihang Li, Hyunguk Kwon, Drué Seksinsky, Daniel Doleiden, Jacqueline O'Connor, Yuan Xuan, Michel Akiki, and James Blust</i>	
<b>GT2021-59162</b> .....	<b>V03AT04A041</b>
Development and Integration of the Dual Fuel Combustion System for the MGT Gas Turbine Family	
<i>Bernhard Čosić, Frank Reiß, Marc Blümer, Christian Frekers, Franklin Genin, Judith Pähr, and Dominik Waßmer</i>	
<b>GT2021-59164</b> .....	<b>V03AT04A042</b>
Numerical Investigation on the Flow Characteristics in a Cover-Plate Pre-Swirl System	
<i>Menghua Jian, Xuesen Yang, and Wei Dong</i>	
<b>GT2021-59170</b> .....	<b>V03AT04A043</b>
Characterization of a Newly Designed Test Bench for Investigations of Flame-Wall-Interaction	
<i>Rahand Dalshad, Tobias Sander, and Michael Pfitzner</i>	
<b>GT2021-59202</b> .....	<b>V03AT04A044</b>
CO Emission Modeling in a Heavy Duty Annular Combustor Operating With Natural Gas	
<i>R. Meloni, S. Gori, A. Andreini, and P. C. Nassini</i>	
<b>GT2021-59203</b> .....	<b>V03AT04A045</b>
A Numerical Study on the Influence of Hydrogen Addition on Soot Formation in a Laminar Aviation Kerosene (Jet A1) Flame at Elevated Pressure	
<i>Mingshan Sun and Zhiwen Gan</i>	
<b>GT2021-59215</b> .....	<b>V03AT04A046</b>
A Novel LES-Based Process for NOx Emission Assessment in a Premixed Swirl Stabilized Combustion System	
<i>R. Meloni, A. Andreini, and P. C. Nassini</i>	
<b>GT2021-59226</b> .....	<b>V03AT04A047</b>
Numerical Study of Thermal Performance and NOx Emission for An Ammonia-Fuelled Micro-Combustor With Ring-Shaped Ribs in Lean Combustion	
<i>Siliang Ni and Dan Zhao</i>	
<b>GT2021-59236</b> .....	<b>V03AT04A048</b>
Development and Atmospheric Testing of a High Hydrogen FlameSheet™ Combustor for the OP16 Gas Turbine	
<i>Thijs Bouten, Jan Withag, Lars-Uno Axelsson, Joris Koomen, Diethard Jansen, and Peter Stuttaford</i>	
<b>GT2021-59267</b> .....	<b>V03AT04A049</b>
Thermoacoustic Stability Analysis of a Full-Annular Lean Combustor for Heavy-Duty Applications	
<i>Daniele Pampaloni, Antonio Andreini, Alessandro Marini, Giovanni Riccio, and Gianni Ceccherini</i>	
<b>GT2021-59306</b> .....	<b>V03AT04A050</b>
High Speed OH PLIF Measurements of Combustor Effusion Films in a High Pressure, Liquid Fueled Combustor	
<i>Aravind Chandh, Shivam Patel, Oleksandr Bibik, Subodh Adhikari, David Wu, Reza Rezvani, Dustin Davis, Tim Lieuwen, and Benjamin Emerson</i>	
<b>GT2021-59321</b> .....	<b>V03AT04A051</b>
A Non-Compact Effective Impedance Model for Can-to-Can Acoustic Communication: Analysis and Optimization of Damping Mechanisms	
<i>Jakob G. R. von Saldern, Alessandro Orchini, and Jonas P. Moeck</i>	
<b>GT2021-59351</b> .....	<b>V03AT04A052</b>
Response of Autoignition-Stabilized Flames to One-Dimensional Disturbances: Intrinsic Response	
<i>Harish S. Gopalakrishnan, Andrea Gruber, and Jonas Moeck</i>	

<b>GT2021-59380</b> .....	<b>V03AT04A053</b>
LES Based CFD Investigation of the Ignition Process in Lean Spray Burner	
<i>A. Andreini, M. Amerighi, L. Palanti, and B. Facchini</i>	
<b>GT2021-59387</b> .....	<b>V03AT04A054</b>
Scale Resolving CFD Investigations of Aerothermal Field and Emissions of a Lean Burn	
Aeroengine Combustor	
<i>S. Paccati, L. Mazzei, A. Andreini, S. Patil, S. Shrivastava, D. Bessette, C. Arguinzoni,</i>	
<i>and R. Yadav</i>	
<b>GT2021-59392</b> .....	<b>V03AT04A055</b>
A Numerical Sensitivity Study of Modeling Parameters in the Combustion of a Swirler	
<i>Saja H. Al-Rifai, Cheng-Xian Lin, Brian T. Bohan, and Marc D. Polanka</i>	