

**Proceedings of ASME Turbo Expo 2023:
Turbomachinery Technical
Conference and Exposition**

(GT2023)

Volume 13D

**June 26-30, 2023
Boston, Massachusetts**

Conference Sponsor
International Gas
Turbine Institute

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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

© 2023, 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: 978-0-7918-8711-0

TABLE OF CONTENTS

Probabilistic CFD Analysis of a High-Pressure Compressor Under Consideration of Manufacturing and In-Service Variability <i>Lukas Schluter, Matthias Voigt, Robin Schmidt, Bernd Becker, Ronald Mailach</i>	1
Surrogate Models for 3D Finite Element Creep Analysis Acceleration <i>Jason Abdallah, Stefan Depeweg, Maria Kuznetsova, Behnam Nouri</i>	13
Shape Optimization of a Cooling Hole Using Improved Metamodeling Techniques and Workflow <i>Adam Norman, Carlo Arguinzoni, Kalyan Sharma, Pat Cunningham, Dibesh Joshi</i>	22
Optimization of Variable Geometry Turbine Electric Turbocharger for a Heavy-Duty, On-Highway Fuel Cell <i>Alexander H. Taylor, Pavan Naik, Simon Nibler, Nisar Al-Hasan</i>	33
Gradient-Free Aerodynamic Optimization With Structural Constraints and Surge Line Control for Radial Compressor Stage <i>Robert Schaffrath, Eberhard Nicke, Nicolai Forsthofer, Oliver Kunc, Christian Voss</i>	42
Gas Turbines Cantilever Nozzles Simplified Approach for Performance and Structural Optimization <i>Andrea Fardelli, Giacomo Ragni, Daniele Di Benedetto, Alessandro De Luca, Simone Colantoni</i>	56
High-Dimensional Uncertainty Quantification of High-Pressure Turbine Vane Based on Multi-Fidelity Deep Neural Networks <i>Zhihui Li, Francesco Montomoli, Nicola Casari, Michele Pinelli</i>	62
Aerodynamic Design and Performance Optimization of a Centrifugal Fan Impeller <i>Gokhan Avsar, Ahmet Alper Ezertas, Ozge Baskan Percin</i>	73
Research on Automatic Aerodynamic Performance Optimization for Flue Gas Turbine Blades Under Multiple Conditions <i>He Yao, Cai Liu-Xi, Yao Jia-Wei, Hou Yan-Fang, Li Yun</i>	92
Realtime CFD Based Shape Optimization Using Geometric Deep Learning for Families of Turbomachinery Applications <i>Alexandre Gouttiere, Giacomo Alessi, Dirk Wunsch, Luca Zampieri, Charles Hirsch</i>	104
An Automated Gaussian Process Integrated With Bayesian Optimization Approach to Designing Spline-Based Pin-Fin Arrays <i>Susheel Dharmadhikari, Reid A. Berdanier, Karen A. Thole, Amrita Basak</i>	116
Comparison Between Gradient-Free and Gradient-Based Optimizations of the SRV2 Radial Compressor <i>Arnaud Chatel, Tom Verstraete</i>	128
Robust Design of Herringbone Grooved Journal Bearings Using Multi-Objective Optimization With Artificial Neural Networks <i>Soheyl Massoudi, Jurg Schiffmann</i>	138
Sensitivity Analysis of Performance Parameters of a Compressor Blade With Correlated Profile Parameters <i>Andriy Prots, Lukas Schluter, Matthias Voigt, Marcus Meyer, Ronald Mailach</i>	151

Advantages of Machine Learning Methods in Aerodynamic Blade Optimization	163
<i>Klajdi Beqiraj, Andrea Perrone, Marco Sanguineti, Gianluca Ricci</i>	
Rapid Algorithmic Blade Design Applying Machine Learning From Shape Optimization to Satisfy Multidisciplinary Constraints	175
<i>Kingshuk Dasadhikari, Yoshihiro Kuwamura</i>	
Acoustic and Aerodynamic Performance of Serrated Leading Edges on the Bypass Outlet Guide Vanes	187
<i>Cleopatra Cuciumita, Ning Qin, Shahrokh Shahpar, Howoong Namgoong</i>	
Cross Boundary Design Optimization Using Simulation Process and Data Management	198
<i>Ken Malton, Ricardo Paiva, Akin Keskin, Atif Riaz, Christos Mourouzidis</i>	
Physics-Driven Priors for Improved Spatial Models and Averages.....	209
<i>Pranay Seshadri, Andrew B. Duncan, George Thorne, Raul Vazquez</i>	
Thermodynamic Optimization of the Cooling System of a High-Pressure-Turbine Blade	221
<i>Barbara Fiedler, Yannick Muller, Matthias Voigt, Ronald Mailach</i>	
Adapting Artificial Neural Networks Training Algorithms to Adjoint-Based Aerodynamic Shape Optimization.....	232
<i>Fernando Gisbert, David Cadrecha, Jaime Quintanal, Adrian Sotillo, Jesus Pueblas, Aida Serrano, Ricardo Puente, Roque Corral</i>	
Multi-Objective Numerical Optimization of Radial Turbines	245
<i>Christopher Fuhrer, Nikola Kovachev, Damian M. Vogt, Ganesh Raja Mahalingam, Stuart Mann</i>	
A Novel Multi-Fidelity Surrogate for Turbomachinery Design Optimization.....	255
<i>Qineng Wang, Liming Song, Zhendong Guo, Jun Li, Zhenping Feng</i>	
Modification of a Radial Pump Characteristics With Fluid Suction in the Vaneless Space.....	265
<i>Sabri Deniz</i>	
Diffuser Stall Inception in a High-Pressure Ratio Centrifugal Compressor With Fishtail Pipe Diffuser.....	277
<i>Atsushi Ogino, Ryo Nakayama, Eijiro Kitamura, Nobumichi Fujisawa, Satoshi Aoyama, Yutaka Ohta</i>	
A Numerical Investigation of the Design Point Performance for a Centrifugal Compressor With a Parameterized Volute	287
<i>Laura McLaughlin, Charles Stuart, Stephen Spence, Daniel Rusch, Marco Geron, Kwok Kai So, Erich Kreiselmair</i>	
Investigating the Suitability of Multi-Scroll Volutes for Improving Spanwise Incidence of Mixed Flow Turbine Rotors With Varying Blade Cone Angles in Automotive Turbocharging Applications.....	299
<i>Peter Martin, Stephen Spence, Charles Stuart, Andre Starke, Thomas Leonard, Marco Geron</i>	
Pressure Characteristic Rollover of a Transonic Centrifugal Impeller	312
<i>Teng Cao, Yoshihiro Hayashi, Isao Tomita</i>	
A CFD-Assisted Throughflow Approach for the Map Calculation of Centrifugal Compressors	326
<i>Sandra Labat Casajust, Daniel Moller, Peter Jeschke</i>	

Investigation on the Influence of Surface Roughness of Rotating Microchannel on Flow Conditions	339
<i>Krzysztof Rusin, Włodzimierz Wroblewski, Sebastian Rulik, Mohammadsadegh Pahlavanzadeh, Emad Hasani Malekshah</i>	
A Piston Theory-Based Aeroelastic Stability Prediction Toolbox for Radial Turbomachinery	347
<i>Vincent Iskandar, David W. Fellows, Daniel J. Bodony, Sang-Guk Kang, Aaron J. Pope, Chol-Bum Kweon</i>	
A Two-Step Approach for Centrifugal Compressor Performance Mapping Based on a Reduced-Order Model and an Evolutionary Algorithm.....	355
<i>Marco Bicchi, Davide Biliotti, Lorenzo Toni, Michele Marconcini, Angelo Grimaldi, Andrea Arnone</i>	
Hysteresis Effect of Volute on Compressor Performance Under Pulsating Flow Condition	367
<i>Yoshihiro Hayashi, Aakeen Parikh, Maria Esperanza Barrera-Medrano, Ricardo Martinez-Botas</i>	
Windage Loss and Flow Characteristics in Back Gap of Radial Inflow Impellers With Steam Medium	377
<i>Zhuobin Zhao, Qinghua Deng, Lehao Hu, Jun Li, Zhenping Feng</i>	
A Critical Analysis on the Impact of External Losses on the Performance of a Centrifugal Compressor Stage - Experimental and Multi-Fidelity Numerical Assessment.....	387
<i>Alberto Baroni, Iacopo Catalani, Luca Romani, Marco Bicchi, Francesco Balduzzi, Michele Marconcini, Alessandro Bianchini, Andrea Arnone, Giovanni Ferrara, Lorenzo Toni, Davide Biliotti</i>	
Loss Analysis in Radial Inflow Turbines for Supercritical CO ₂ Mixtures	399
<i>Omar Aqel, Martin White, Abdulnaser Sayma</i>	
Aerodynamic Design, Study, and Performance Mapping of a Radial-Axial Machine for Geothermal Power Plants in Energy Transition Applications	414
<i>Fabrizio Lottini, Michele Marconcini, Andrea Arnone, Davide Biliotti, Alice Foschini</i>	
Empirical Loss Model Optimization for the Prediction of Centrifugal Compressor Off-Design Performance.....	429
<i>Jonathon Howard, Peter Knudsen, Abraham Engeda</i>	
Role of the Inducer in Flow Instability of a High-Speed Centrifugal Compressor Impeller	447
<i>Meijie Zhang, Wangxia Wu</i>	
Numerical and Experimental Investigation of Riblet-Coating Impact on Centrifugal Compressor Stage Performance.....	457
<i>Sophia Jorg, Manfred Wirsum, Mikel Lucas Garcia De Albeniz, Peter Leitl, Andreas Flanschger, Yvonne Kowalik, Philipp Jenny</i>	
NASA Small Engine Components Compressor Test Facility: High Efficiency Centrifugal Compressor Vaneless Diffuser and Transition Duct Configurations	469
<i>Herbert M. Harrison, Ezra O. McNichols, Matthew R. Blaha</i>	
A Novel Optimisation of a Transonic Centrifugal Impeller Based on 3D Inverse Design Approach.....	481
<i>Peng Wang, Mingding Zhang, Mehrdad Zangeneh</i>	
A Method for Preliminary Design of Variable Geometry Vaned Diffuser for Centrifugal Compressor.....	493
<i>Hideaki Tamaki, Satoshi Yamaguchi</i>	

Investigation on the Unsteady Surge Flow Behavior of an Axial-Centrifugal Compressor	507
<i>Jiaan Li, Mengyang Wen, Baotong Wang, Xinqian Zheng</i>	
Robust Design of a Vaned Diffuser in a Centrifugal Compressor Stage With a High Load Impeller	518
<i>Andrea Agnolucci, Michele Marconcini, Davide Biliotti, Lorenzo Toni, Alberto Baroni, Luca Romani, Andrea Arnone</i>	
Conceptual Design of the Electric Pumps for the High-Performance Engine of a European Lunar Lander.....	528
<i>Piero Danieli, Massimo Masi, Riccardo Tridello, Mario Pessana, Francesco Barato, Alessandro Chiesa</i>	
Innovative Lightweight Compression System Based on Axial-Centrifugal Contra-Rotating Concept: Pushing the Limits	538
<i>Akchhay Kumar, Chetankumar Mistry, Sankar Kumar, Ajay Pratap</i>	
Integrated Aero-Mechanical Design and Experimental Validation for Next Generation Compressors for Energy Transition.....	555
<i>Lorenzo Toni, Alberto Guglielmo, Angelo Grimaldi, Francesco Cangioli, Davide Biliotti, Elisabetta Belardini, Giulia Meazzini, Lorenzo Miris</i>	
On the Feasibility of Helicity-Based Corrections of Turbulence Models for Improving RANS Predictions of Centrifugal Compressor Stages	565
<i>Alessandro Pela, Michele Marconcini, Andrea Arnone, Lorenzo Toni, Roberto Valente, Andrea Agnolucci, Angelo Grimaldi, Roberto Pacciani</i>	
The Effect of Unsteady Inlet Boundary Conditions on the Aero-Thermal Behavior of High-Pressure Turbine Vanes: A Numerical Study Using Scale-Resolving Simulations	577
<i>Jonathan Grundler, Knut Lehmann, Heinz-Peter Schiffer</i>	
Numerical Characterization of Pre-stall Disturbances in a Compressor Stage	590
<i>Victor Bicalho Civinelli de Almeida, Ergin Tuzuner, Mario Eck, Dieter Peitsch</i>	
CFD Simulations of the Unsteady-State Flow Through a 1.5-Stage High-Work Turbine.....	606
<i>Thorsten Hansen, Erik Munkell, Georg Scheuerer, Qingyuan Zhuang, Kim Zwiener</i>	
A Numerical Test Rig for Turbomachinery Flows Based on Large Eddy Simulations With a High-Order Discontinuous Galerkin Scheme - Part 3: Secondary Flow Effects	618
<i>Christian Morsbach, Michael Bergmann, Adem Tosun, Bjorn F. Klose, Patrick Bechlars, Edmund Kugeler</i>	
A Numerical Test Rig for Turbomachinery Flows Based on Large Eddy Simulations With a High-Order Discontinuous Galerkin Scheme - Part 1: Sliding Interfaces and Unsteady Row Interactions	631
<i>Michael Bergmann, Christian Morsbach, Bjorn F. Klose, Graham Ashcroft, Edmund Kugeler</i>	
Investigation of the Stability and Surge Limit in an Industrial Centrifugal Compressor With Variable Inlet Guide Vanes	646
<i>Julian Stemmermann, Loic Marc Reymond, Marius Geilich, Peter Jeschke</i>	
Boundary Layer Analysis of a Transonic High-Pressure Turbine Vane Using Ultra-Fast-Response Temperature-Sensitive Paint.....	656
<i>Anna Petersen, Michael Hilfer</i>	
A Numerical Test Rig for Turbomachinery Flows Based on Large Eddy Simulations With a High-Order Discontinuous Galerkin Scheme - Part 2: Shock-Capturing and Transonic Flows	668
<i>Bjorn F. Klose, Christian Morsbach, Michael Bergmann, Alexander Hergt, Joachim Klinner, Sebastian Grund, Edmund Kugeler</i>	

Coherent Turbulent Stresses in Unsteady Forced Transonic Nozzle With Shock-Induced Separation	681
<i>Nicolas Goffart, Benoit Tartinville, Sergio Pirozzoli</i>	
Investigation of the Aerodynamic Losses Caused by the Impeller/Volute Interaction in a Transonic Centrifugal Compressor.....	691
<i>Loic Marc Reymond, Marius Geilich, Julian Stemmermann, Peter Jeschke</i>	
Direct Numerical Simulation of an HPT Stage: Unsteady Boundary Layer Transition and the Resulting Flow Structures	704
<i>Taiyang Wang, Yaomin Zhao, John Leggett, Richard D. Sandberg</i>	
Analysis of Flutter Mechanisms and Unsteady Aerodynamics of a Transonic Fan Blade Near Stall.....	717
<i>Roger Zoepke-Sonntag, George Hill, Sina Stapelfeldt</i>	
Experimental Characterization of Surge Cycles in a Centrifugal Compressor Under Wet Gas Operation.....	729
<i>Alberto Serena, Oyvind Hundseid, Lars Eirik Bakken</i>	
Unsteady Pre-Stall Behavior in a Centrifugal Compressor With Vaned Diffuser.....	740
<i>Yutaro Suzuki, Nobumichi Fujisawa, Yutaka Ohta</i>	
Investigations of the Unsteady Shock-Boundary Layer Interaction in a Transonic Compressor Cascade.....	752
<i>Edwin J. Munoz Lopez, Alexander Hergt, Joachim Klinner, Sebastian Grund, Jirair Karboujian, Jasmin Flamm, Volker Gummer</i>	
Numerical Investigations of Near Surge Operating Conditions in a Two-Stage Radial Compressor With Refrigerant Gas.....	764
<i>Carlo Cravero, Davide Marsano, Vishnu Sishtla, Chaitanya Halbe, William T. Cousins</i>	
The Role of Turbulence Transport in Mechanical Energy Budgets.....	779
<i>Pawel J. Przytarski, Davide Lengani, Daniele Simoni, Andrew P. S. Wheeler</i>	
Characterising the Unsteady Flow-Field in Low-Flow Turbine Operation	793
<i>Hye Rim Kim, Lennart Stania, Niklas Maroldt, Marcel Oettinger, Joerg R. Seume</i>	
The Impact of the Off-Design Conditions on the Entropy Wave Interaction With a High-Pressure Turbine Stage.....	806
<i>Lorenzo Pinelli, Giovanni Giannini, Michele Marconcini, Roberto Pacciani, Andrea Notaristefano, Paolo Gaetani</i>	
Impact of High-Pressure-Turbine Purge Flow on the Evolution of Turbulence in a Turbine Vane Frame.....	820
<i>Asim Hafizovic, Filippo Merli, Nicolas Krajnc, Malte Schien, Andreas Peters, Franz Heitmeir, Emil Gottlich</i>	
Exploring Physics of Acoustic Flow Control Over Airfoils Towards Potential Application to High Work and Lift Turbines.....	834
<i>Acar Celik, Abhijit Mitra, Tapish Agarwal, John Clark, Ian Jacobi, Beni Cukurel</i>	
Unsteady Pressures During Frequency Lock-in of a Cylinder Experiencing Non-Synchronous Vibrations	850
<i>Richard Hollenbach, Isabelle Sanz, Robert Kielb</i>	
A Machine Learning Approach for the Prediction of Time-Averaged Unsteady Flows in Turbomachinery.....	859
<i>Dominik Blechschmidt, Dajan Mimic</i>	

Unsteady Flow Structure of Corner Separation in a Highly Loaded Compressor Cascade..... 877
Weibo Zhong, Yangwei Liu, Yumeng Tang

Author Index