

4th International Supercritical CO₂ Power Cycles Symposium

September 9-10, 2014

Sponsored by
U.S. Department of Energy | Office of Fossil Energy | National Energy Technology Laboratory



U.S. DEPARTMENT OF
ENERGY





TABLE OF CONTENTS

Synopsis.....	3
Technology Summary	3
Organizing Committee	3
Agenda-At-A-Glance.....	4
Sheraton Station Square Floor Plan.....	5
Detailed Program for Monday, September 8, 2014	6
Detailed Program for Tuesday, September 9, 2014	6
Detailed Program for Wednesday, September 10, 2014.....	9
Speaker/Presenter Biographies.....	13



SYNOPSIS

The 4th International Supercritical CO₂ Power Cycles Symposium is a technical meeting organized and designed by industry, academia, and government agencies to advance the development of power cycles with supercritical carbon dioxide (CO₂) as the working fluid. Every two to three years, researchers, industry, and end users meet to learn about advancements in the field, discuss priorities, and establish a critical path for technology development. The first symposium was held at the Massachusetts Institute of Technology in 2007, the second was held at Rensselaer Polytechnic Institute in 2009, and the third was held at the University of Colorado at Boulder in 2011. The technical papers and presentations for the 2014 symposium will be available online following the symposium, archived alongside those of the previous workshops. An underlining approach to the symposium format is to facilitate peer-to-peer knowledge sharing and collaboration across boundaries that will create a network of expertise and accelerate advancements in the field.



TECHNOLOGY SUMMARY

Supercritical CO₂ power cycles can provide cost and performance benefits to fossil, renewable, and nuclear power plants. The potential for greater thermal efficiency from this cycle leads to more power per unit of fuel which ultimately reduces power plant operating costs and emissions. The higher thermal efficiency will also reduce plant capital cost per unit of power produced. The nature of the power cycle and the working fluid make it likely that turbo machinery will be more compact and less costly. Carbon dioxide is an attractive working fluid because it reaches a critical state at reasonable temperatures and pressures, it is non-toxic, it can be easily obtained, and it is inexpensive. These properties make supercritical CO₂ a good choice compared to other working fluids including superheated steam, helium, and organic fluids. To realize these performance and cost benefits several key technology issues must be overcome including turbomachinery design, recuperator design and cost reduction, materials assessment and development, and cycle operational considerations to name a few. A main purpose of this symposium is to help resolve these technology development issues.



ORGANIZING COMMITTEE

Ganesan (Subbu) Subbaraman / Aerojet Rocketdyne

Robert Fuller / Barber-Nichols

Eric Clementoni / Bechtel Marine Propulsion

Kenneth Kimball / Bechtel Marine Propulsion

Steve Wright / Critical Energy

Rene Pecnic / Delft University of Technology

Tom Logan / Dresser-Rand

Tim Held / Echogen

David Thimsen / EPRI - Electric Power Research Institute

Max Powers / General Electric

Renaud Le Pierres / HEATRIC

Jeong Ik Lee / KAIST

Craig Turchi / National Renewable Energy Laboratory

Jim Pasch / Sandia National Laboratories

Klaus Brun / Southwest Research Institute

Lalit Chordia / Thar Energy

David Sánchez / University of Seville

Jesse Gary / US DOE - Office of Energy Efficiency and Renewable Energy

Richard Dalton / Leonardo Technologies Inc.

Rich Dennis / US DOE - Office of Fossil Energy NETL

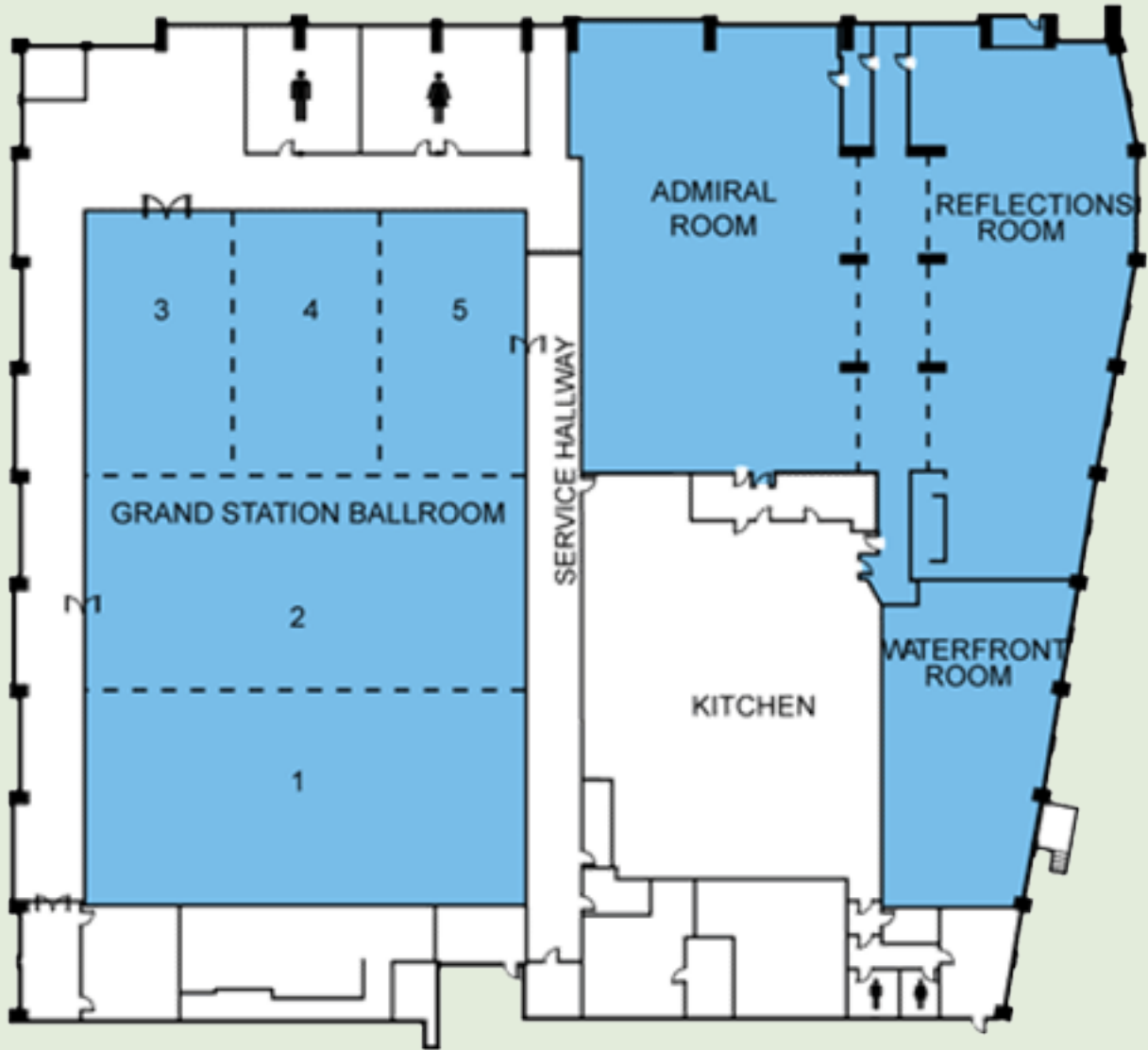
Steve Reeves / US DOE - Office of Nuclear Energy

AGENDA AT-A-GLANCE

	Tutorials/Technical Track 1 Grand Station 1 & 2	Technical Track 2 Admiral Room	Technical Track 3 Grand Station 3-5
MONDAY, SEPTEMBER 8TH			
3:00 pm	Registration (Grand Station Foyer)		
7:00 pm	Industry Sponsored Reception - Thomas Alley, EPRI (Reflections Room)		
TUESDAY, SEPTEMBER 9TH			
7:00 am	Registration (Grand Station Foyer) Continental Breakfast (Waterfront Room)		
8:00 am	Welcome and Preliminaries (Grand Station 1 & 2) - <i>Richard Dennis, NETL</i>		
8:15 am	Department of Energy Keynote Panel (Grand Station 1 & 2) - <i>Darren Mollot, Office of Fossil Energy; Sal Golub, Office of Nuclear Energy; Jesse Gary, Office of Energy Efficiency and Renewable Energy</i>		
9:45 am	Coffee Break / Poster Session (Waterfront Room)		
10:15 am	Industry Panel Discussion (Grand Station 1 & 2) - <i>Thar Energy, Barber Nichols, Dresser-Rand, Echogen, Aerojet Rocketdyne, General Electric</i>		
12:00 pm	Lunch (Reflections Room)		
1:00 pm	Tutorial: Introduction to sCO ₂ Power Cycles	TESTING I Papers: 1, 10, 11, 25, 26 Chair: Ken Kimball	TURBOMACHINERY I Papers: 22, 35, 36, 46, 74 Chair: Ken Kimball
2:00 pm	Tutorial: sCO ₂ Heat Exchangers		
3:05 pm	Coffee Break / Poster Session* (Waterfront Room)		
3:30 pm	Tutorial: Turbo Machinery Design for sCO ₂ Applications	SYSTEM CONCEPTS I Papers: 6, 9, 18, 72 Chair: Mark Spector	PHYSICAL PROPERTIES I Papers: 94, 27, 58, 62, 78 Chair: Craig Turchi
4:45 pm	SYSTEM MODELING & CONTROL I Papers: 17, 30 Chair: Eric Clementoni		
6:00 pm	Dinner (Reflections Room) - <i>Frank Princiotto, EPA</i>		
WEDNESDAY, SEPTEMBER 10TH			
7:00 am	Registration (Grand Station Foyer)		
8:00 am	HEAT EXCHANGERS I Papers: 5, 7, 13, 19 Chair: Renaud Le Pierres	SYSTEM MODELING & CONTROL II Papers: 37, 43, 44, 45 Chair: David Sánchez	SYSTEM CONCEPTS II Papers: 40, 50, 63, 68, 29 Chair: Steve Wright
10:05 am	Coffee Break / Poster Session* (Waterfront Room)		
10:30 am	TURBOMACHINERY II Papers: 51, 59, 66, 79 Chair: Tim Held	HEAT EXCHANGERS II Papers: 59, 93 Chair: Subbu Subbaraman	SYSTEM MODELING & CONTROL III Papers: 49, 67, 70, 76 Chair: Jim Pasch
12:10 pm	Lunch (Reflections Room)		
1:30 pm	TESTING II Papers: 28, 33, 47, 71, 95 Chair: Rich Dennis	SYSTEM CONCEPTS III Papers: 69, 73, 75, 31, 84 Chair: Jeong Ik Lee	MATERIALS I Papers: 2, 3, 32, 61, 64 Chair: Voramon Dheeradhada
3:35 pm	Coffee Break / Poster Session (Waterfront Room)		
4:00 pm	R&D Panel Discussion (Grand Station 1 & 2) - <i>SwRI, DOE NREL, Bechtel Marine Propulsion, University of Seville, Sandia National Lab, NETL</i>		
5:30 pm	Farewell and Adjourn - <i>Symposium Co-Chairs Klaus Brun, SwRI, and Richard Dennis, NETL</i>		

*Posters on display all day Tuesday and Wednesday in the Waterfront Room.

SHERATON STATION SQUARE FLOOR PLAN



FIRST FLOOR

DETAILED PROGRAM

MONDAY, SEPTEMBER 8TH

EARLY REGISTRATION

3:00 PM – 7:00 PM in the Grand Station Foyer

INDUSTRY SPONSORED RECEPTION

7:00 PM – 9:00 PM in the Reflections Room

- **Introduction** - *Klaus Brun, Southwest Research Institute*
- **New Fossil Power Generation Options to Meet a Changing Mission Profile** - *Thomas Alley, Vice President of Generation, Electric Power Research Institute (EPRI)*

TUESDAY, SEPTEMBER 9TH

REGISTRATION

7:00 AM – 8:00 AM in the Grand Station Foyer

CONTINENTAL BREAKFAST

7:00 AM – 8:00 AM in the Waterfront Room

WELCOME AND PRELIMINARIES

8:00 AM – 8:15 AM in Grand Station 1 & 2

Rich Dennis, U.S. Department of Energy, National Energy Technology Laboratory

DEPARTMENT OF ENERGY KEYNOTE PANEL

8:15 AM – 9:45 AM in Grand Station 1 & 2

Introduction/Moderator: – Rich Dennis, U.S. Department of Energy, National Energy Technology Laboratory

- *Darren Mollot, Director, Office of Advanced Fossil Energy Technology, U.S. Department of Energy*
- *Sal Golub, Associate Deputy Assistant Secretary for Nuclear Reactor Technologies, Office of Nuclear Energy U.S. Department of Energy*
- *Jesse Gary, Technology Development Manager, Concentrating Solar Power, SunShot Initiative, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy*

COFFEE BREAK AND POSTER SESSION

9:45 AM – 10:15 AM in the Waterfront Room

INDUSTRY DISCUSSION PANEL

10:15 AM – 12:00 PM in Grand Station 1 & 2

Introduction/Moderator: Lalit Chordia, Thar Energy

- *Tom Logan, Dresser Rand*
- *Tim Held, Echogen*
- *Bob Fuller, Barber-Nichols*
- *Maxwell Peter, GE Global Research*
- *Don Stevenson, Aerojet Rocketdyne*

DETAILED PROGRAM

TUESDAY, SEPTEMBER 9TH

LUNCH

12:00 PM – 1:00 PM in the Reflections Room

TUTORIALS

1:00PM – 3:05 PM in Grand Station 1 & 2

1. **Introduction to sCO₂ Power Cycles** - *Jason Wilkes, Southwest Research Institute; Grant Musgrove, Southwest Research Institute*
2. **sCO₂ Heat Exchangers** - *Grant Musgrove, Southwest Research Institute; Renaud Le Pierres, Heatric; Shaun Sullivan, Brayton Energy*

SESSION – TESTING I

1:00 PM – 3:05 PM in the Admiral Room

Session Chairs – Ken Kimball and Ganesan (Subbu) Subbaraman

1. **Installation of the Supercritical CO₂ Compressor Performance Test Loop as a First Phase of the SCIEL Facility** - *Yoonhan Ahn, Korea Atomic Energy Research Institute*
2. **Steady-State Power Operation of a Supercritical Carbon Dioxide Brayton Cycle** - *Eric Clementoni, Bechtel Marine Propulsion Corporation*
3. **Practical Aspects of Supercritical Carbon Dioxide Brayton System Testing** - *Eric Clementoni, Bechtel Marine Propulsion Corporation*
4. **The Effect of Supercritical Power Cycles at Hydrogen Production Plants** - *Petr Hájek, UJV Rez, a.s.*

SESSION – TURBOMACHINERY I

1:00 PM – 3:05 PM in Grand Station 3 – 5

Session Chairs – Klaus Brun and Tom Logan

1. **Pressure Actuated Leaf Seal Technology Readiness Testing** - *Clayton Grondahl, CMG Tech*
2. **Uncertainty on performance measurement of S-CO₂ compressor operating near the critical point** - *Jekyoung Lee, Korea Atomic Energy Research Institute*
3. **An Investigation of Condensation Effects in Supercritical Carbon Dioxide Compressors** - *Claudio Lettieri, Massachusetts Institute of Technology*
4. **Exploring the Design Space of the sCO₂ Power Cycle Compressor** - *David Sánchez*
5. **Development of High Efficiency Hot Gas Turbo-Expander for Optimized CSP Supercritical CO₂ Power Block Operation** - *C.J. Kalra, GE Global Research*

COFFEE BREAK AND POSTER SESSIONS

3:05 PM – 3:30 PM in the Waterfront Room

TUTORIAL

3:30 PM – 4:45 PM in Grand Station 1 & 2

1. **Turbo Machinery Design for sCO₂ Applications** - *Jeff Moore, Southwest Research Institute*

DETAILED PROGRAM

TUESDAY, SEPTEMBER 9TH

SESSION – SYSTEM MODELING AND CONTROL I

4:45 PM – 6:00 PM in Grand Station 1 & 2

Session Chairs: Eric Clementoni and Craig Turchi

1. **Development of a Flexible Modeling Tool for Predicting Optimal Off-Design Performance of Simple and Recompression Brayton Cycles** - *John Dyreby, University of Wisconsin-Madison*
2. **Supercritical CO₂ Brayton Recompression Cycle Design and Control Features to Support Startup and Operation** - *Michael Hexemer, Bechtel Marine Propulsion Corporation*

SESSION – SYSTEM CONCEPTS I

3:30 PM – 6:00 PM in the Admiral Room

Session Chairs: Mark Spector and Rich Dennis

1. **Study of a Supercritical CO₂ Power Cycle Application in a Cogeneration Power Plant** - *Leonid Moroz, SoftInWay*
2. **Recent Advances in Power Cycles Using Rotating Detonation Engines with Subcritical and Supercritical CO₂** - *Scott Claflin, Aerojet Rocketdyne*
3. **Component Technology Maturity & Cost of Electricity for sCO₂ Brayton Power Cycle in Nuclear, Solar & Fossil Heat Sources: Development Challenges and Mitigation Approaches** - *Tony Eastland, Aerojet Rocketdyne*
4. **A Novel sCO₂ Primary Cycle for Air-Combustible Fuels** - *David Stapp, Peregrine Turbine Technologies, LLC*

SESSION – PHYSICAL PROPERTIES I

3:30 PM – 6:00 PM in Grand Station 3 – 5

Session Chairs: Craig Turchi and Jim Pasch

1. **Study of a Supercritical CO₂ Power Cycle Application in a Cogeneration Power Plant** - *Vincent Lijo, Daejoo Machinery Co., Ltd.*
2. **Progress Toward New Reference Correlations for the Transport Properties of Carbon Dioxide** - *Allan Harvey, National Institute of Standards and Technology*
3. **Experimental Investigation of Effects of Buoyancy on Supercritical Carbon Dioxide Heat Transfer in Round Tubes** - *Sandeep Pidaparti, Georgia Institute of Technology, Atlanta*
4. **High Pressure Thermophysical Gas Property Testing, Uncertainty Analyses, and Equation of State Comparison for Supercritical CO₂ Compression Applications** - *Brandon Ridens, Southwest Research Institute*
5. **Research on the Effect of Moving the Pinch Point in cycles with Supercritical Carbon Dioxide** - *Ladislav Vesely, Czech Technical University in Prague, Faculty of Mechanical Engineering*

DINNER

6:00 PM – 8:00 PM in the Reflections Room

- **Introduction** - *Ganesan (Subbu) Subbaraman*
- **Global Climate Change –The Quantifiable Sustainability Challenge** - *Frank Princiotta, Director, Air Pollution Prevention & Control Division National Risk Management Research Laboratory Office of Research & Development, U. S. Environmental Protection Agency (EPA)*

DETAILED PROGRAM

WEDNESDAY, SEPTEMBER 10TH

REGISTRATION

7:00 AM – 8:00 AM in the Grand Station Foyer

CONTINENTAL BREAKFAST

7:00 AM – 8:00 AM in the Waterfront Room

SESSION – HEAT EXCHANGERS I

8:00 AM – 10:05 AM in Grand Station 1 & 2

Session Chairs: Renaud Le Pierres and Seth Lawson

1. **Development of a Direct Supercritical Carbon Dioxide Solar Receiver Based on Compact Heat Exchanger Technology** - *Saeb Besarati, Clean Energy Research Center/University of South Florida*
2. **Options for SCO₂ Brayton Cycle Heat Exchangers** - *Matthew Carlson, Sandia National Laboratories*
3. **Comparison of Measured and Analytical Performance of Shell-and-Tube Heat Exchangers Cooling and Heating Supercritical Carbon Dioxide** - *Timothy Cox, Bechtel Marine Propulsion Corporation*
4. **Compact Recuperators for a Supercritical CO₂ Brayton Power Cycle** - *Patrick Fourspring, Bechtel Marine Propulsion Corporation*

SESSION – SYSTEM MODELING AND CONTROL II

8:00 AM – 10:05 AM in the Admiral Room

Session Chairs: David Sánchez and Tim Held

1. **Comparison of System Control, Compressor and Turbine Test Results to Performance Predictions for the Supercritical CO₂ (S-CO₂) Closed Loop Brayton Cycle** - *Kevin Rahner, Bechtel Marine Propulsion Corporation*
2. **Thermodynamic Optimization of Recuperated S-CO₂ Brayton Cycles for Waste Heat Recovery Applications** - *Mahmood Mohagheghi, University of Central Florida*
3. **Investigation of a Dry Air Cooling Option for an S-CO₂ Cycle** - *Anton Moisseytsev, Argonne National Laboratory*
4. **Recent Developments in the S-CO₂ Cycle Dynamic Modeling and Analysis at ANL** - *Anton Moisseytsev, Argonne National Laboratory*

SESSION – SYSTEM CONCEPTS II

8:00 AM – 10:05 AM in Grand Station 3 – 5

Session Chairs: Steven Wright and Jeong Ik Lee

1. **Technical and Economic Evaluation of Supercritical Oxy-Combustion for Fossil Power Generation** - *Aaron McClung, Southwest Research Institute*
2. **Comparison of Supercritical CO₂ Gas Turbine Cycle and Brayton CO₂ Gas Turbine Cycle for Solar Thermal Power Plants** - *Yasushi Muto, Research Associate of Tokyo Institute of Technology*
3. **Commercializing the Recompression Closed Brayton Cycle** - *Gary E. Rochau, Sandia National Laboratories*
4. **An Assessment of Supercritical CO₂ Power Cycles Integrated with Generic Heat Sources** - *Charles White, U.S. Department of Energy, National Energy Technology Laboratory*
5. **Increasing Systems Engineering Efficiency for NASA's Earth to Orbit Group and Sandia National Laboratory's Recompression Closed Brayton Cycle R&D InitiativeS with the Process Management Tool VdotTM** - *Roger Herdy, CFD Research Corporation*

DETAILED PROGRAM

WEDNESDAY, SEPTEMBER 10TH

COFFEE BREAK

10:05 AM – 10:30 AM in the Waterfront Room

SESSION – TURBOMACHINERY II

10:30 AM – 12:10 PM in Grand Station 1 & 2

Session Chairs: Tim Held and Lalit Chordia

1. **Achievable Efficiency and Stability of Supercritical CO₂ Compression Systems** - *Jeff Noall, Sandia National Laboratories*
2. **Experimental and Numerical study of Supercritical Carbon Dioxide flow through Labyrinth Seals** - *Haomin Yuan, Georgia Institute of Technology*
3. **Study of a Supercritical CO₂ Turbine with TIT of 1350 K for Brayton Cycle with 100 MW Class Output: Aerodynamic Analysis of Stage 1** - *Joshua Schmitt, University of Central Florida*
4. **Integrally Geared Compressors for sCO₂** - *René Dittmer, MAN Diesel & Turbo SE*

SESSION – HEAT EXCHANGERS II

10:30 AM – 12:10 PM in the Admiral Room

Session Chairs: Ganesan (Subbu) Subbaraman and Mark Spector

1. **Numerical Analysis of a Fin Arrangement for an Optimal Design of Airfoil Fin PCHE** - *Hyun Sun Park, Postech*
2. **Polygon Expansion Engine Waste Heat Energy sCO₂ Recovery Cycle Thermodynamic Analysis and Component Design** - *Kevin Anderson, Cal Poly Pomona, Mechanical Engineering*

SESSION – SYSTEM MODELING AND CONTROL III

10:30 AM – 12:10 PM in Grand Station 3 – 5

Session Chairs: Jim Pasch and Ken Kimball

1. **Advanced Exergetic Analysis as a Tool for the Thermodynamic Evaluation of Supercritical CO₂ Power Cycles** - *George Tsatsaronis, Technical University Berlin*
2. **Mapping the Design Space of a Recuperated, Recompression, Precompression Supercritical Carbon Dioxide Power Cycle with Intercooling, Improved Regeneration, and Reheat** - *Andy Schroder, University of Cincinnati*
3. **Improving Performance of Extremum Seeking Control Applied to a Supercritical CO₂ Closed Brayton Cycle in a Solar Thermal Power Plant** - *Rajinesh Singh, School of Mechanical and Mining Engineering, The University of Queensland*
4. **Supercritical CO₂ Turbomachinery Configuration and Controls for a Zero Emission Coal Fired Power Plant: System Off Design & Control of System Transients** - *Tony Eastland, Aerojet Rocketdyne*

LUNCH

12:10 PM – 1:30 PM in the Reflections Room

DETAILED PROGRAM

WEDNESDAY, SEPTEMBER 10TH

SESSION – TESTING II

1:30 PM – 3:35 PM in Grand Station 1 & 2

Session Chairs: Rich Dennis and David Sánchez

1. **Initial Test Results of a Megawatt-Class Supercritical CO₂ Heat Engine** - *Timothy Held, Echogen Power Systems, LLC*
2. **Supercritical Carbon Dioxide Brayton Cycle Development Overview** - *Kenneth Kimball, Bechtel Marine Propulsion Corporation*
3. **Development of 1MWe Supercritical CO₂ Test Loop** - *Jeff Moore, Southwest Research Institute*
4. **Supercritical CO₂ Heat Exchanger Fouling** - *Alan Kruiuzenga, Sandia National Laboratories*
5. **Film Riding Leaf Seals for Improved Shaft Sealing** - *Clay Grondahl, CMG Tech*

SESSION – SYSTEM CONCEPTS III

1:30 PM – 3:35 PM in the Admiral Room

Session Chair: Jeong Ik Lee and David Thimsen

1. **Utilization of the Supercritical CO₂ Brayton Cycle with Sodium-Cooled Fast Reactors** - *James Sienicki, Argonne National Laboratory, Nuclear Engineering Division*
2. **Technology Needs for Fossil Fuel Supercritical CO₂ Power Systems** - *Peter Strakey, U.S. Department of Energy, National Energy Technology Laboratory*
3. **Design Considerations for Concentrating Solar Power** - *Craig Turchi, U.S. Department of Energy, National Renewable Energy Laboratory*
4. **Thermodynamics of sCO₂ Recompression Brayton Cycle** - *Megan Huang, Aerojet Rocketdyne*
5. **Bulk Energy Storage using a Supercritical CO₂ Waste Heat Recovery Power Plant** - *Steven Wright, SuperCritical Technologies Inc.*

SESSION – MATERIALS I

1:30 PM – 3:35 PM in Grand Station 3 – 5

Session Chair: Voramon Dheeradhada and Eric Clementoni

1. **Materials Corrosion in High Temperature Supercritical Carbon Dioxide** - *Jacob Mahaffey, University of Wisconsin-Madison*
2. **Nickel-Base Superalloys for Advanced Power Systems - An Alloy Producer's Perspective** - *Brian Baker, Special Metals Corporation*
3. **Tensile properties of Structural Materials Aged in High-Temperature S-CO₂ Environment** - *Jang Changheui, Korea Atomic Energy Research Institute*
4. **The Effect of Temperature on the sCO₂ Compatibility of Conventional Structural Alloys** - *Bruce Pint, Oak Ridge National Laboratory*
5. **Corrosion Testing of High Temperature Materials in Supercritical Carbon Dioxide** - *Henry Saari, Carleton University*



DETAILED PROGRAM

WEDNESDAY, SEPTEMBER 10TH

COFFEE BREAK

4:00 PM – 4:30 PM in the Waterfront Room

R&D PANEL DISCUSSION

4:30 PM – 6:00 PM in Grand Station 1 & 2

Research & Development on SCO₂ Power Cycles to Address Industry Needs

Introduction/Moderator: Klaus Brun, Southwest Research Institute

- *Craig Turchi, DOE NREL*
- *Brian Morris, Bechtel Marine Propulsion / Knolls Atomic Lab*
- *David Sánchez, University of Seville*
- *Gary Rochau, Sandia National Laboratories*
- *Peter Strakey, DOE NETL*

FAREWELL AND ADJOURN

6:00 PM

Symposium Co-Chairs:

Klaus Brun, Southwest Research Institute

Rich Dennis, U.S. Department of Energy, National Energy Technology Laboratory

PRESENTER BIOGRAPHIES



YOONHAN AHN

Ahn, Yoonhan is Ph.D candidate in the department of Nuclear and Quantum Engineering in Korean Advanced Institute of Science and Technology (KAIST). He has been researched the supercritical carbon dioxide (sCO₂) cycle designs and modeling.



THOMAS ALLEY

Thomas Alley is Vice President of Generation for the Electric Power Research Institute (EPRI).

In this role he is responsible for the R&D team which is focused on research, development, and the application of fossil technologies for both existing and future generating assets. He has 29 years of experience in the energy industry and his experience includes fossil and nuclear power. He joined EPRI in 2007 as senior program manager for major component reliability R&D, and most recently served as director of advanced generation research, which includes renewable generation, carbon capture and storage, generation planning, and industry technology demonstrations.

Before joining EPRI, Alley worked at Duke Energy, leading a centralized corporate team of metallurgists, engineers, and technical personnel responsible for the evaluation, inspection, and repair of nuclear power plant components. He began his career at Duke Energy as a materials engineer responsible for the metallurgy, inspection, and repair of fossil power plant components.

Alley received a Bachelor of Science degree in electrical engineering and a Bachelor of Science degree in materials engineering from North Carolina State University. He is a registered professional engineer in North Carolina and South Carolina.



KEVIN R. ANDERSON

Dr. Kevin R. Anderson, P.E. is a Professor of Mechanical Engineering at California State Polytechnic University at Pomona (Cal Poly Pomona). Dr. Anderson received his BSME from Cal Poly in 1991, his MSME from CU Boulder in 1994, and his Ph.D. from CU Boulder in 1998 in the area of Combustion. Currently, Dr. Anderson is the Director of the Solar Thermal Alternative Renewable Energy Lab. Dr. Anderson holds over 15 years of consulting experience in the private sector of engineering. Dr. Anderson's publications are listed on www.csupomona.edu/~kranderson1 and his areas of expertise include Thermal and Fluid Analysis, CFD Simulation, Alternative and Renewable Energy Technology Development and Design.



SAEB M. BESARATI

Saeb M. Besarati is a Ph.D. candidate in the University of South Florida and works as a research assistant in Clean Energy Research Center. He received his Master's degree in Mechanical Engineering from the University of Guilan, Iran. His Ph.D. dissertation is entitled as "Analysis of supercritical carbon dioxide power cycles for concentrated solar power applications." His main research interests are modeling and optimization of energy systems. He has contributed in writing two book chapters and 14 refereed technical papers.

PRESENTER BIOGRAPHIES

KLAUS BRUN

Dr. Klaus Brun is the Program Director of the Machinery Program at Southwest Research Institute. His experience includes positions in engineering, project management, and management at Solar Turbines, General Electric, and Alstom. He holds six patents, authored over 150 papers, and published two textbooks on gas turbines. Dr. Brun won an R&D 100 award in 2007 for his Semi-Active Valve invention and ASME Oil & Gas Committee Best Paper awards in 1998, 2000, 2005, 2009, 2010, and 2012. He was chosen to the “40 under 40” by the San Antonio Business Journal. He is the past chair of the ASME-IGTI Board of Directors and the past Chairman of the ASME Oil & Gas Applications Committee. He is also a member of the API 616 and 692 Task Forces, the Middle East Turbomachinery Symposium, the Fan Conference Advisory Committee, and the Supercritical CO₂ Conference Advisory Committee. Dr. Brun is the Executive Correspondent of Turbomachinery International Magazine and an Associate Editor of the ASME Journal of Gas Turbines for Power.

MATTHEW CARLESON

Matthew Carlson is a Member of Technical Staff at Sandia National Laboratories. Matthew was a Critical Skills Masters Fellow at the University of Wisconsin – Madison where he earned both his masters and undergraduate degrees in mechanical engineering, with honors in research and a certificate in international engineering.

His current research interests include thermal-hydraulic and mechanical design and evaluation of heat exchange equipment for energy production.



SCOTT CLAFLIN

Scott Claflin has been involved in advancing the state of the art in propulsion technology for the past 27 years. He currently serves as Director of Power Innovations at Aerojet Rocketdyne where he oversees fast-paced development of high power density technologies and products. He received a B.S. degree in aerospace engineering from the University of Kansas and an M.S. degree in aeronautical and astronautical engineering from Purdue University

ERIC CLEMENTONI

Eric Clementoni is the lead engineer for Bechtel Marine Propulsion Corporation’s Integrated System Test which is being operated at the Bettis Atomic Power Laboratory. Eric received a Bachelor of Science degree in Chemical Engineering from Rose-Hulman Institute of Technology in 2004 and has worked on various advanced design and development projects at the Bettis Atomic Power Laboratory ever since. Since 2010, Eric has led efforts focused on the final design, construction, and operation of the Integrated System Test.

TIMOTHY COX

Timothy Cox is presently a Principal Engineer with Bechtel Marine Propulsion Corporation, where he is Lead Mechanical Engineer for the Integrated Systems Test supercritical carbon dioxide Brayton power cycle project. Prior to joining BMPC in 2005, Dr. Cox spent over 15 years in industrial research and development with Alcoa, Inc., Danieli Wean, and Weirton Steel Corporation. Dr. Cox earned his Ph.D. in mechanical engineering at Carnegie Mellon University, and has M.S. and B.S. degrees in aerospace engineering from West Virginia University.

PRESENTER BIOGRAPHIES

DAVID M. CUSANO

Dr. David M. Cusano – VP and owner of Parametric Solutions Inc. David is Chief Engineer in Flow and Heat Transfer. His responsibilities include technical leadership in computational fluid dynamics, secondary flow, thermal analysis, instrumentation and data acquisition, business development, and information technology. David graduated from Purdue University with a Ph.D. in Mechanical Engineering in 1999 after working as an analytical engineer at Pratt and Whitney in Jupiter, FL from 1989-1992. Prior to that, David graduated from University of Michigan with a Master of Science in Aerospace Engineering in 1989 and from University of Illinois with a Bachelor of Science in Aeronautical/Astronautical Engineering in 1988.



RICHARD A. DENNIS

Mr. Richard Dennis is the Turbine Technology Manager and the Advanced Combustion Technology Manager at the U.S. Department of Energy's National Energy Technology Laboratory (NETL). Rich has a BS and MS in Mechanical Engineering from West Virginia University. From 1983 to 1992 Mr. Dennis worked in the on-site research group of NETL where he conducted research related to pressurized fluidized bed combustion, coal gasification and gas stream particulate cleanup for advanced coal based power generation. From 1993 to 2000 Mr. Dennis managed contracted research in advanced fossil fuel power generation including coal combustion and gasification, fuel cells, and gas turbines. In 2002 Richard was selected as the Turbine Technology Manager and in 2014 was asked to help manage the Advanced Combustion Technology area. Richard is active in ASME and the International Gas Turbine Institute.

VORAMON DHEERADHADA

Voramon Dheeradhada is a research scientist at GE Global Research in Niskayuna. Prior to joining General Electric, Voramon received her Master's and Ph.D. from Materials Science and Engineering Department, Purdue University. Her research is focused on high temperature structural materials including high temperature degradation behavior of metallic alloys and coatings; diffusion and thermodynamic modeling, and microstructure – property relationship. She is a part of a team at GE Global Research to study lifing methodology for supercritical CO₂ turbomachinery.



RENÉ DITTMER

René Dittmer obtained Degree in Process Engineering at the FHTW Berlin, Germany, in 2002. In the same year René joined the company “Vogelsang” for the realization of experimental findings on rotary lobe pumps. The main focus is a precise Performance prediction under various wear conditions and with various, even multiphase fluids.

René Dittmer joined MAN Diesel & Turbo in 2003 as a Project Manager Sales and Contracts for the Berlin Refinery and Oil & Gas division for Centrifugal Compressors. His main activities are the elaboration and negotiation of technical and commercial contracts with clients, worldwide in different applications.

As the integrally geared compressor concept became more and more accepted in Oil and Gas industry he specialized for this type of compressor.



PRESENTER BIOGRAPHIES

JOHN JAMES DYREBY

John graduated in August from the University of Wisconsin-Madison with a Ph.D. in mechanical engineering, where his research focused on the development of models suitable for predicting the off-design performance of SCO_2 power cycles. John is also a principal at Northland Numerics, a company whose aim is to provide tools and resources to facilitate scientific software development. Through his work at Northland Numerics, John developed the Fluid Property Interpolation Tables (FIT) library. The FIT library, which is available for a number of languages, provides fluid property subroutines with accuracy comparable to REFPROP at a fraction of the computational cost. With his student career officially over, John plans to dedicate his time to Northland Numerics and hopes he can stay involved in the sCO_2 power cycle community.

PATRICK FOURSPRING

Dr. Fourspring is currently responsible for the development of heat exchanger technology for a closed Brayton power cycle using supercritical carbon dioxide as the working fluid. This development includes the CO_2 -to-water heat exchanger for heat rejection, a CO_2 -to- CO_2 recuperator heat exchanger, and a water-to- CO_2 heat exchanger for heat addition. The development has identified configurations, fabrication techniques, and development partners in order to design, fabricate, and test prototype heat exchangers. Dr. Fourspring is the primary author or contributing author on a few dozen technical papers.

Dr. Fourspring's engineering experience spans three decades with two organizations focused on nuclear power. From 1980 to 1990, he was associated with the Duke Power Company (now Duke Energy) in support of their operating, nuclear power stations. In 1994 he joined the Knolls Atomic Power Laboratory. During this time, he has lead or participated in several development programs that include the following: spectral control development for thermophotovoltaic energy conversion in order to improve efficiency and power density, a diagnostic system for emergency diesel generators to improve startup reliability and thus the safety posture of the nuclear power system, and development of a probabilistic brittle fracture design methodology.

CLAY GRONDAHL

Clay Grondahl is a gas turbine consultant with a focus on seal technology development. He is retired from GE Power Systems where he provided engineering and project management for the modification and performance improvement of operating GE gas turbines with installation of new and advanced technology components including seals. Earlier in his GE career he designed gas turbine rotating components and contributed to several advanced technology projects at the GE Corporate Research and Development Center and in GE Power Systems. His career started in the US Navy where he served on nuclear submarines making Polaris patrols and qualifying as Chief Engineer for the onboard nuclear steam plant.

PETR HAJEK

Dr. Petr Hajek is the head of mechanical design team in UJV; he has 35 years of experience in nuclear power plant development, mainly in quality assurance and in design of experimental devices for the testing reactor LVR-15 in UJV, Rez, for testing some elements of GIV reactors, and also for ITER.

PRESENTER BIOGRAPHIES



ALLAN H. HARVEY

Allan Harvey is a Chemical Engineer with the Theory and Modeling of Fluids Group of the Applied Chemicals and Materials Division at the National Institute of Standards and Technology (NIST) in Boulder, Colorado. He specializes in the application of molecular concepts for the prediction and correlation of thermophysical properties of fluids and fluid mixtures; this work encompasses both fluids of interest for measurement science (such as helium) and those of interest for industry (such as water/steam and carbon dioxide).

Allan received a B.S. in Chemical Engineering from the University of Missouri at Rolla (now Missouri University of Science and Technology) in 1983, and a Ph.D. in Chemical Engineering from the University of California at Berkeley in 1988. He did postdoctoral work with the Thermophysics Division of NIST (Gaithersburg, MD) and worked for Simulation Sciences, Inc. (a process design software company) before rejoining NIST in 1994.



TIMOTHY HELD

Timothy Held is the Chief Technology Officer at Echogen Power Systems. He joined Echogen in October 2008, where he led the development of their commercial Supercritical CO₂ Power Cycle engines. Previously, he was with GE Aviation for 13 years, where he led the Commercial Engine Combustor and Industrial Aero-derivative Combustor Aero Design groups, and was the technical leader for alternate fuels research and evaluation. Dr. Held received his Ph.D. from Princeton University in 1993.



ROGER HERDY

Roger Herdy started his career at the Air Force's Arnold Engineering Development Center, where he worked in the Special Projects group testing emerging aerospace technologies. He then joined the contractor community at NASA MSFC, where he managed the design and development of test facilities and served as a test engineer. He has managed diverse programs for both Commercial and Government customers. He holds two patents in propulsion, and multiple patents for advanced oxidizers pending. He holds a BS in Mechanical Engineering from the University of Kentucky and a MS in Engineering Management from the University of Tennessee. He currently is the Chief Systems Engineer for CFDRC in Huntsville, Alabama, and a Senior Member of AIAA.



MEGAN HUANG

Megan Huang is a Systems Engineer and has worked at Aerojet Rocketdyne for 4 years. She received a B.S. in Chemical Engineering from Columbia University in 2010 and an M.S. in Chemical Engineering from the University of Southern California in 2014. Megan has worked on a number of projects at AR related to supercritical CO₂ processes, Direct Steam Generator and Downhole Steam Generator system performance, green propellant analysis and testing, and liquid rocket engine test matrix formulation.

PRESENTER BIOGRAPHIES

CHANGHEUI JANG

Prof. Changheui Jang is at the department of Nuclear and Quantum Engineering in KAIST, Korea. He got the Ph.D in the Nuclear Engineering at MIT in 1995 with the study of the welding of Ni-base superalloys for Fusion Reactor application. Since then, he had mostly worked in Nuclear Industry dealing with material ageing issues like irradiation embrittlement, thermal ageing, corrosion-related cracking, etc. After he moved to KAIST in 2004, he resumed his interest in high temperature materials for nuclear application. His current research interests include the understanding of the ageing phenomena and high temperature oxidation, evaluation of welded joint, and development of surface modification methods for the advanced nuclear power systems including high temperature reactors, fusion reactor, and advanced water reactors. Also, he recently started a research program on materials issues in SCO₂ environments focusing on the performance evaluation of the austenitic alloys and diffusion bonding of those materials.

ZHIJUN JIA

Dr. Zhijun Jia, the main founder of CompRex, formerly worked in Chart Industries and has extensive experience in designing and engineering for diffusion bonded and brazed exchangers. The company is able to use patented technology from Chart in diffusion bonded product which can serve for heat exchangers and reactors. The company is partnered with Robinson Metal to manufacture the product with the ASME code stamp.



C.J. KALRA

Chiranjeev Kalra is a Mechanical Engineer at GE Global Research Center in Niskayuna, NY. He received B.S. and M.S. in Mechanical Engineering from Delhi University and Drexel University respectively, and Ph.D. in Mechanical and Aerospace Engineering from Princeton University in 2010. Chiranjeev is currently leading multiple programs related to supercritical CO₂ power cycles and turbomachinery development and commercialization at GE. He has authored more than 25 technical papers in peer reviewed journals & conferences and submitted 12 patent applications, 2 granted. His primary research interests include turbomachinery design, fluid mechanics, thermodynamic-economic optimization of energy systems, and heat transfer.

KEN KIMBALL

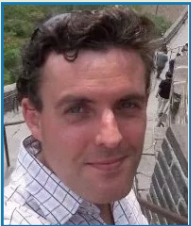
Ken Kimball has been actively involved with supercritical CO₂ Brayton power cycle development since 2005 working at the Knolls Atomic Power Laboratory in Schenectady, NY, USA. This effort has included working closely with numerous University, National Laboratory and Industry groups. He has a BS degree in mechanical engineering from Worcester Polytechnic Institute and an MS degree in mechanical engineering from Rensselaer Polytechnic Institute. He has previously presented development progress at the supercritical CO₂ Brayton power cycle development symposiums in 2009 and 2011 and the ASME Turbo Conferences in 2012 and 2013.

PRESENTER BIOGRAPHIES

ALAN M. KRUIZENGA

Dr. Alan M. Kruizena is a mechanical and nuclear engineer with specialties in experimental design, thermo hydraulics, next generation power cycles, and materials corrosion. Dr. Kruizena is a Senior Member of the Technical Staff at Sandia National Laboratories in Livermore, California.

Prior to working for Sandia, Dr. Kruizena was a Nuclear Regulatory Fellow at the University of Wisconsin-Madison where he completed his Ph.D. in Nuclear Engineering and Engineering Physics in August 2010. He also holds masters degrees in Nuclear Engineering and Engineering Physics and Mechanical Engineering from the University of Wisconsin. Dr. Kruizena received his B.S. degree in Physics from the University of Wisconsin-River Falls. His research at the University of Wisconsin focused on Micro Channel Supercritical Carbon Dioxide Heat Transfer Measurements for Brayton Cycle Regenerators. His current work at Sandia focuses on materials aspects of high temperature power cycles.



RENAUD LE PIERRES

Renaud Le Pierres has Bachelor degrees in Mechanical Engineering, Beng equivalent in France and BSc(Hons) in Hull University and a MSc in Portsmouth University where he contributed to several research projects ranging from optical fibres manufacturing improvement to new Friction Surfacing coating developments.

He followed these studies by designing pressure vessels and pressure filter housings used in food, pharmaceutical and nuclear industries for 3 years before joining Heatric in 2005 as a Design Engineer within the newly created Nuclear Department. There he developed his heat exchangers design skills on various Gen IV power conversion cycles concepts, including SCO₂ Closed Brayton Cycles.

He is regularly attending conferences on new Power Conversion Cycles since 2006 and presented several papers and panels relating to SCO₂ CBC over that time both as Design Engineer and more recently as Business Development Engineer.

JEKYOUNG LEE

Ph.D. Candidate at Korea Advanced Institute of Science and Technology. Author has nuclear engineering background, both of bachelor's and master's degree were granted with nuclear engineering. The bachelor's degree was obtained from Hanyang University in Korea at 2011 and master's degree was obtained from Korea Advanced Institute of Science and Technology at 2013. Main research topic is SCO₂ compressor. SCO₂ compressor design and analysis, experiment are current research issues.



JEONG IK LEE

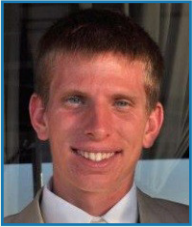
Jeong Ik LEE was educated at Seoul National University in Seoul, Korea until 2003, from the Department of Nuclear Engineering. In 2005 and 2007 he completed his MSc and PhD degrees, respectively in Nuclear Science and Engineering from Massachusetts Institute of Technology, Cambridge, USA. After then he was hired by a nuclear engineering consulting company FNC Co., Ltd. as a research scientist to participate in various Korean nuclear industry related projects. More than a half year experience in the company, he then carried out postdoctoral research in general energy system analysis at KAIST Institute of Eco-energy. In July 2010 he took up an assistant professorship in KAIST and he moved to UAE in the following month to join Khalifa Univ. as a joint-professor in Nuclear Engineering program. He stayed in UAE for a year and he returned back to Korea to continue his work in KAIST. He is a permanent member of Korean Nuclear Society and a member of American Nuclear Society.

His initial research interest was in the turbulent heat transfer for the next generation nuclear reactor safety. Recently his research area expanded to the development of supercritical CO₂ power conversion system for the next generation nuclear reactor system. The major research topics are the SCO₂ cycle design, turbomachinery and compact heat exchanger design, analysis and experiment. In addition, he is one of the members for initiating a large Korean government project on the development of SCO₂ power conversion system technology.

PRESENTER BIOGRAPHIES

CLAUDIO LETTIERI

Dr. Lettieri obtained his Dipl. Ing. degree in Aerospace Engineering at University of Naples, and his master's and doctoral degrees at Imperial College London in Mechanical Engineering. Following a post-doctoral fellowship, he works as a Research Engineer at the Gas Turbine Laboratory of the Massachusetts Institute of Technology (MIT) since 2012. His work is funded by NASA and Mitsubishi Heavy Industries and his research focuses on unsteady, two-phase flows and turbomachinery for aerospace propulsion and power generation systems.



JACOB MAHAFFEY

Jacob Mahaffey is a research assistant under Dr. Mark Anderson. His research focuses on corrosion of materials in supercritical carbon dioxide environments. He attended Carthage College where he received his BA in Physics and Chemistry in 2013.

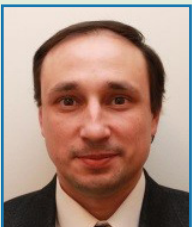
AARON MCCLUNG

Aaron McClung, Ph.D. is a Senior Research Engineer with the Machinery Program at Southwest Research Institute. Dr. McClung received his B.S. and M.S. from Oklahoma State University and his Doctorate from the Air Force Institute of Technology. Dr. McClung's interests are in the areas of fluid dynamics, fluid-structure interaction, and numerical simulation. At SwRI, Dr. McClung is leading efforts developing Oxy-Combustion based Supercritical Carbon Dioxide power cycles, is developing advanced pulsation control techniques for natural gas compression, and is leading process and component evaluation testing for Liquefied Natural Gas production.



MAHMOOD MOHAGHEGHI

Mahmood received his first M.Sc. in Energy Systems Engineering from Sharif University of Technology and second M.Sc. in Mechanical Engineering from University of Central Florida. He currently works as a research assistant and Ph.D. candidate at University of Central Florida. Mahmood's primary research areas are SCO₂ power cycles, waste heat to power, combined heat and power, heat recovery steam generator, solar thermal energy, concentrated solar power, modeling and optimization of thermal power plants, thermo-economics, exergy analysis, and genetic algorithm.



ANTON MOISSEYTSEV

Anton Moisseytsev is a Principal Computational Nuclear Engineer at Nuclear Engineering Division of Argonne National Laboratory. He is a member of the Innovative Nuclear Systems Development section. He has ten years of experience in modeling and simulation of various reactor systems, including design and analysis of the advanced reactors and energy conversion systems, safety analysis of nuclear reactors, and code development for steady-state and transient simulations of nuclear power plants.

Anton has been involved in the development of the supercritical carbon dioxide Brayton cycle at Argonne since 2002. He is responsible for the development of the computational models and computer codes for the analysis of the SCO₂ cycle. Anton Moisseytsev has developed an automatic control strategy for a SCO₂ cycle and carried out safety and transient analysis of several fast reactor systems with SCO₂ energy converter.

Anton Moisseytsev received Ph.D. degree from Texas A&M University in 2003.

PRESENTER BIOGRAPHIES



JEFFREY MOORE

Dr. Jeffrey Moore is the manager of the Rotating Machinery Dynamics Section at Southwest Research Institute in San Antonio, TX. He holds a B.S., M.S., and Ph.D. in Mechanical Engineering from Texas A&M University. His professional experience over the last 20 years includes engineering and management responsibilities related to centrifugal compressors and gas turbines at Solar Turbines Inc. in San Diego, CA, Dresser-Rand in Olean, NY, and Southwest Research Institute in San Antonio, TX. His interests include advanced power cycles and compression methods, rotordynamics, seals and bearings, computational fluid dynamics, finite element analysis, machine design, controls and aerodynamics. He has authored over 30 technical papers related to turbomachinery and has one patent issued and two pending. Dr. Moore has held the position of Oil and Gas Committee Chair for IGTI Turbo Expo and is the Associate Editor for the Journal of Tribology. He is also a member of the IGTI SCO₂ Committee, Turbomachinery Symposium Advisory Committee, the IFToMM International Rotordynamics Conference Committee, and the API 616 and 684 Task Forces.



LEONID MOROZ

Dr. Leonid Moroz, the founder of SoftInWay, has extensive experience in the turbomachinery field. Upon graduation from Kharkov Polytechnic Institute (Ukraine) in 1982, Dr. Moroz held various positions at NPO TURBOATOM prior to founding SoftInWay to design, analyze and optimize axial and radial turbines and compressors.

Since 1999, his company, SoftInWay Inc., has been offering extensive expertise through training and consulting services, developing efficient turbomachinery and creating its flagship software, AxSTREAM™ - for flow path design, redesign, analysis, and optimization. The company recently released its AxCYCLE™ software, designed to simulate full thermodynamic cycles including SCO₂ cycle.



GRANT O. MUSGROVE

Grant O. Musgrove is a Research Engineer in the Machinery Program at Southwest Research Institute. He currently conducts applied research for turbomachinery applications in the Oil & Gas and power generation industries. His active research areas are wet gas compression, supercritical CO₂, and turbomachinery design. Mr. Musgrove's responsibilities range from technical analysis to project management for both experimental and computational activities. Mr. Musgrove graduated from Oklahoma State University in 2007 and from The Pennsylvania State University in 2009 with B.S. and M.S. degrees in Mechanical Engineering, respectively.

YASUSHI MUTO

Mr. Yasushi Muto graduated a master course of Nuclear Engineering of Tokyo University in 1967. As an employee of the Japan Atomic Energy Research Institute, he engaged in the design and research works for the High Temperature Gas-Cooled Reactor.

Since retired in September 2002, he is engaged in the research works for the supercritical CO₂ gas turbine as a research associate in the Research Laboratory for Nuclear Reactors of the Tokyo Institute of Technology.

PRESENTER BIOGRAPHIES

JEFF NOALL

Jeff Noall is a staff engineer at Barber Nichols Inc., where he has been responsible for the aerodynamic/hydrodynamic design of compressors, turbines and pumps for a number of different projects over a wide range of applications. While at Barber Nichols, Jeff has been involved with several pioneering projects related to supercritical CO₂ power cycles. Prior to joining Barber Nichols in 2005, Jeff was part of the Turbine Aerodynamics group at Pratt & Whitney where he worked primarily on the F135 engine project during his 4 ½ years at the company. Jeff has a Master's degree in Mechanical Engineering from Brigham Young University.



JIM PASCH

Dr. Jim Pasch has professional experience in four distinct fields. In 1995, he supported the Air Force Air Combat Training Systems program as a systems engineer in Fort Walton Beach, Florida. In 1998, Pratt & Whitney hired Jim as a member of their rocket propulsion systems team in West Palm Beach, Florida. Jim spent eight years in this capacity analyzing test and flight data from the Space Shuttle Main Engine. Jacobs Engineering hired Jim in 2006 as NASA ramped up the Constellation program to replace the aging shuttle fleet. While working at Marshall Space Flight Center, Jim was tasked with analyzing and quantifying various thermal hydraulic and control risks to the successful launch of the Ares I-X mission. In 2010, Sandia National Labs hired Jim for his thermodynamic and thermal hydraulic expertise, first to support the nuclear waste disposal program in Carlsbad, New Mexico, then to take over as the principal investigator for Sandia closed Brayton cycle R&D efforts in Albuquerque.

SANDEEP PIDAPARTI

Sandeep received his Bachelor's degree in Mechanical Engineering from National Institute of Technology - Kurukshetra, India in 2011. Since 2012, he has been working on a DOE funded project performing experiments and simulations to model heat exchangers and labyrinth seals for the sCO₂ cycle. He recently received his Master's degree in Mechanical Engineering from Texas A&M University, College Station and is currently pursuing a PhD degree in Mechanical Engineering at Georgia Institute of Technology, Atlanta.



BRUCE PINT

Bruce Pint is the Group Leader of the Corrosion Science & Technology Group in the Materials Science & Technology Division at Oak Ridge National Laboratory. He received his Ph.D. from M.I.T. in Ceramic Science and Engineering in 1992 and has been at ORNL since 1994. Dr. Pint is the principal investigator for numerous R&D projects including corrosion issues in fossil energy, nuclear energy, fusion energy and combined heat and power systems. His research covers compatibility, lifetime predictions, environmental effects and coatings in all types of power generation. In 2014, he was named a Fellow of NACE International and ASM International.

FRANK PRINCIOTTA

Frank Princiotta is Director of the Air Pollution Prevention and Control Division (APPCD) of the National Risk Management Research Laboratory. He has a degree in Chemical Engineering (Tau Beta Pi) and a Nuclear Engineering Certificate from the Oak Ridge School of Reactor Technology. As Director of APPCD, in Research Triangle Park, NC, he is responsible for R&D for methods and technologies for controlling and characterizing air pollution from major sources. He has been a key agency expert in air pollution control for over 30 years; he has been the recipient of a gold medal, four EPA bronze medals for his accomplishments in the air pollution control field. He has also received the President's Meritorious Executive Award on two separate occasions. He played the leadership role in the development and demonstration of sulfur dioxide pollution control technology for coal-fired boilers, which has been the mainstay of SO₂ control worldwide. An author of many scientific papers on air pollution control & climate change mitigation, he has been a frequent speaker before technical societies and conferences and has chaired numerous symposia and has testified before House and Senate Committees on air pollution control. Recently he has focused on global climate. He has analyzed the role that technology will need to play, if we are to avoid the potentially catastrophic impacts associated with an unconstrained and uncontrolled use of energy.

PRESENTER BIOGRAPHIES



HENRY SAARI

Dr. Saari received his PhD in Aerospace Engineering from Carleton University in 2003. His PhD research was part of a collaborative research program between Carleton University, Pratt and Whitney Canada, and the Institute for Aerospace Research, National Research Council Canada on the development and modelling of directionally solidified titanium aluminide alloys. He is currently Associate Professor in the Department of Mechanical and Aerospace Engineering at Carleton University. Dr. Saari's research includes processing, properties, and joining of gas turbine materials, corrosion of materials in supercritical carbon dioxide, and supercritical carbon dioxide Brayton cycle development.



WILLIAM "BILL" SCAMMELL

Bill holds a BA in Business from the University of Puget Sound, and a Master of Business Administration from the University of Washington. He began his professional career in commercial lending, working at Banner Bank in Bellevue, WA for nearly five years before pursuing his MBA. As a graduate student his studies were focused on finance and economics. Travelling to India with a group of fellow students, he acted as a volunteer consultant for an NGO in Ahmedabad, tasked with evaluating funding strategies for a clean energy initiative. Upon completion of the MBA program Bill joined Supercritical Technologies, where he has worked with his colleagues to commercialize distributed generation technology utilizing supercritical carbon-dioxide power cycles.



JOSHUA SCHMITT

Joshua is a Master of Science degree candidate in Mechanical Engineering at the University of Central Florida. His area of focus is thermofluids and heat transfer. The field in which he is most knowledgeable is turbine aerodynamic and thermodynamic design. His research includes: simulation and modelling of supercritical carbon dioxide, design and optimization of thermodynamic cycles, design and optimization of airfoils in turbomachinery, and the study of renewable algal biofuels.

Joshua also currently works as an intern for Siemens Energy in their materials and testing division. His work there includes: development of acoustic sensors for gas turbine applications and validation of cooling channel CFD through heat transfer experiments. He received his Bachelor of Science in Mechanical Engineering from the University of Florida, and he was inducted into the Pi Tau Sigma engineering honor society.

ANDY SCHRODER

Andy Schroder holds a Bachelor's and Master's Degree in Mechanical Engineering from the University of Cincinnati. He is currently a doctoral student of Aerospace Engineering at the University of Cincinnati. Andy's dissertation research has been focused on Supercritical Carbon Dioxide Power Cycles. In the past, Andy has worked as a co-op student on a spacecraft design team, full time as a rotating turbomachinery component test lead, and as a graduate student researcher developing a test rig and conducting numerical simulations of unsteady forced convection heat transfer focused on internal turbine blade cooling. Andy has also worked in the automotive manufacturing industry as a co-op student, and worked for many years in his family's auto salvage and auto salvage industry computer software businesses, dismantling automobiles and developing computer software that has been used by thousands of auto salvage businesses around the world. Andy's dissertation research efforts are currently on a part time basis as he is also taking on consulting projects and is developing and marketing a control system for retail fuel stations to accept Bitcoin for payment directly at their fuel dispensers. Andy has also developed a fully functional micro scale biodiesel production facility and conducts research in the area of solar energy resource availability with a focus on applications of medium temperature solar thermal collectors.

PRESENTER BIOGRAPHIES



JAMES J. SIENICKI

James J. Sienicki is the Manager of the Innovative Systems and Engineering Assessments Section and a Senior Nuclear Engineer in the Nuclear Engineering Division at Argonne National Laboratory (ANL). Jim has thirty-eight years of experience at ANL in nuclear engineering including program development, nuclear power plant design, nuclear power plant analysis, technology database assessment, identification of research and development needs, identification of technology development needs, nuclear power plant safety analysis, development of experiment concepts, analysis of experiments, physical model development, and numerical computer code development. He has worked on the development of Lead-Cooled Fast Reactor (LFR) and Sodium-Cooled Fast Reactor (SFR) Small Modular Reactor (SMR) designs at ANL since 1997, including the lead-cooled SUPERSTAR and sodium-cooled AFR-100. Jim has been leading the development of the supercritical carbon dioxide Brayton cycle at ANL with funding from the U.S. Department of Energy since 2002. He is also involved in the design and analysis of experiments on fundamental phenomena involved in heat exchangers for supercritical CO₂ cycles.



RAJINESH SINGH

Rajinesh Singh graduated with a BE(Hons I) degree in mechanical engineering from the University of Auckland in 2007. He subsequently completed a PhD in mechanical engineering at The University of Queensland in 2013. Dr. Singh is currently a postdoctoral research fellow at The University of Queensland. His main research focus is on dynamics and control of advanced power generation systems including the supercritical CO₂ closed Brayton cycle and direct-steam generation in solar thermal power plants.

MARK SPECTOR

Dr. Mark S. Spector is a Program Officer in the Ships and Engineering Systems Division at the Office of Naval Research where he manages programs in thermal management, metamaterials, and energy conversion. In addition, he sits on the Steering Committee of the Interagency Advanced Power Group, the Department of Defense Energy and Power Community of Interest, and the NATO Applied Vehicle Technology Power and Propulsion Systems Technical Committee. Previously, he spent nine years as a Research Physicist in the Center for Bio/Molecular Science and Engineering at the Naval Research Laboratory. He received his Ph.D. in Physics from the Massachusetts Institute of Technology and his A.B. in Physics and Applied Mathematics from University of California at Berkeley. Dr. Spector has coauthored 51 refereed publications, 3 invited book chapters, and holds 3 patents.



DAVID STAPP

David is a twenty-nine (29) year veteran of aerospace engineering with expertise in turbo-machinery design and analysis (military and commercial, aero and power-gen), UAV aircraft design (both rotary and fixed wing), structural design and analysis including stress and life, vibration, and buckling analysis in a multitude of industries. He holds a BSME from the University of Colorado.

David began his career with GE Aircraft Engines in 1985 working on such projects as T700, GE36, CFE738, F412, GE90, and CF34-8C engines designing rotating engine structures (high and low pressure compressors, high and low pressure turbines). David also conducted the life re-certification analysis for the CT7-5 LPT and similar work for the CT7-9 LPT. In 1996 David founded Peregrine Consulting, Inc. and has served as an expert consultant and engineering services provider to name brand turbomachinery OEMs since then.

His expertise ranges from thermodynamic cycle design, stress and life analysis, modal and vibration analysis, buckling analysis and mechanical design of rotating and structural turbomachinery hardware. His systems level approach to design has led to the invention of the novel cycle presented here.

PRESENTER BIOGRAPHIES

GANESAN SUBBARAMAN

Dr. Ganesan (Subbu) Subbaraman is Energy Systems Business Development Manager for Aerojet Rocketdyne, a business unit of GenCorp based in Sacramento, California. His current responsibilities include conceiving, developing, demonstrating and commercializing game-changing technologies for production of large-scale hydrogen, oil and gas, and electrical power. His customers in these areas include international oil and gas companies, industrial gas companies, electrical utilities, and the U.S. government.

Prior to his current assignment, Dr. Subbaraman was program manager for creating and implementing key initiatives at Rocketdyne including the Compact Hydrogen Generator, Zero Emission Power and Steam (ZEPSTM) and Supercritical CO₂ Brayton power conversion cycle programs. Prior to that, he was project manager for the International Space Station electrical power system, and Technical Program Manager at the U.S Department of Energy's (DOE) Energy Technology Engineering Center (ETEC), operated by Rocketdyne. His technical experience also includes materials development for advanced power plant applications, remote technologies (including fiber-optic based lasers) for hazardous material dismantlement, and beneficial uses of radiation. Prior to joining Aerojet Rocketdyne and its predecessor corporations, he worked at the Institute for Resource Management as a consultant to U.S nuclear utilities.

Dr. Subbaraman received the B.E (Hons.) degree in Metallurgy from the University of Madras, India. He obtained his M.S and Ph. D degrees in Metallurgical Engineering, and Nuclear Science & Engineering, respectively from Virginia Tech. He also holds a Certificate in Program Management from the West Coast University. Dr. Subbaraman has taught undergraduate and graduate engineering courses as an Adjunct Professor at the California State University, Northridge.



SHAUN SULLIVAN

Shaun Sullivan earned his undergraduate degree from RPI and his graduate degree from MIT. After graduating he spent 8 years at Ingersoll-Rand Energy Systems, developing and exercising models to represent and evaluate recuperators, combustors, fuel systems, and alternative-fuel-conditioning systems. In 2008 he joined Brayton Energy, where he continues to develop models for solar, biomass, and supercritical carbon dioxide systems. He is also the Principal Investigator for Brayton Energy's SunShot Program to develop a high-efficiency low-cost supercritical carbon dioxide solar receiver.



GEORGE TSATSARONIS

Professor Tsatsaronis is the Bewag Professor of Energy Engineering and Protection of the Environment at the Technische Universität Berlin, Germany. He received a Diploma in mechanical engineering (NTU Athens, Greece), and an MBA, a Ph.D. in combustion, and a Dr Habilitatus Degree in Thermoeconomics, all from the RWTH Aachen, Germany. In the time period between 1982 and 1994 he worked in the USA at Desert Research Institute (Reno, Nevada), and Tennessee Tech University (Cookeville, Tennessee).

His areas of interest include the design, development, analysis and optimization of energy conversion systems. He contributed significantly to the fundamentals and terminology of exergy-based methods. He co-authored the book *Thermal Design and Optimisation* (Wiley, 1996), has published more than 300 papers, has served as Chairman or Co-chairman of 18 international conferences, and received several international awards and recognitions.

PRESENTER BIOGRAPHIES



JULIE D. TUCKER

Dr. Tucker earned her B.S. in Nuclear Engineering from the University of Missouri – Rolla. She attended graduate school at the University of Wisconsin – Madison as a Naval Nuclear Propulsion Fellow, where she received her M.S. and Ph.D. in Nuclear Engineering with an emphasis in Materials Science in 2008. After graduation, Dr. Tucker spent five years as a Principal Scientist at Knolls Atomic Power Laboratory (KAPL) in Schenectady, NY. In September of 2013, she joined the Mechanical, Industrial, and Manufacturing Engineering department at Oregon State University as an Assistant Professor. Her research efforts are focused on nuclear materials and metallurgy and leverage both modeling and experimental approaches to gain fundamental understanding of materials degradation mechanisms.

CRAIG S. TURCHI

Craig originally joined NREL in 1990 working in the Solar Industrial Program on the detoxification of hazardous waste with solar ultraviolet light. During the 1990s Craig performed system analyses, ran laboratory, pilot, and field tests, and managed cooperative R&D agreements with industry partners.

He returned to NREL in 2008 after spending ten years as a principal investigator and program leader with ADA Technologies Inc., a technology development company in Littleton, CO. Craig joined NREL's Concentrating Solar Power team to assist with systems analysis and the development and assessment of heat-transfer fluids and thermal-storage concepts. In addition to these roles, he oversees the assessment of advanced power cycle designs and utility-scale solar environmental impacts.



LADISLAV VESELY

Ladislav Vesely is a postgraduate student of Czech Technical University in Prague, Department of Energy Engineering. The subject of his PhD thesis is study of thermal cycle with supercritical CO₂. He has been devoted to the study of CO₂ for 4 years. He wrote his bachelor thesis on Component analysis of freezing in cycle with supercritical CO₂ and master thesis on theme Design of small experimental loop with supercritical carbon dioxide. With Research Centre Rez he cooperated on the design of experimental loop with CO₂.



CHRISTIAN WACKER

Christian Wacker obtained a Diploma in Mechanical Engineering at the Technical University of Karlsruhe in 1994. In 1995 he joined the former Babcock Borsig (now MAN Diesel & Turbo SE) in Berlin where he started in the department Aerodynamics, Mechanics and Development.

His main activities included design, measurement and commissioning support for integrally geared compressors. In this function he participated in the field-commissioning of most MAN Turbo high-pressure CO₂-compressors. In the business unit Oil & Gas he is now Head of Team Aero- & Thermodynamics at the Berlin location.

RACHEL WILLIS

Rachel is an undergraduate student in her senior year studying mechanical engineering at the University of Central Florida. She has been an undergraduate research assistant for Dr.Kapat at the CATER laboratory. She is the Vice President of the ASME chapter at the University of Central Florida.



PRESENTER BIOGRAPHIES

STEVEN A. WRIGHT

Dr. Steven A. Wright has his PhD in Nuclear Engineering from the University of Washington and was a distinguished member of technical staff at Sandia National Laboratories (Sandia) with 35 years of experience. While at Sandia, Dr. Wright developed some of the world's first supercritical CO₂ (SCO₂) power systems. After he retired from Sandia in 2011, he briefly offered consulting services for supercritical CO₂ power systems and advanced nuclear reactors.

Dr. Wright is currently a founder of SuperCritical Technologies Incorporated, and is its Chief Scientist. SuperCritical Technologies is a Delaware C and is located in Bremerton Washington. SuperCritical Technologies is developing supercritical CO₂ power platforms, performing SCO₂ risk mitigation experiments, and offering Organic Rankine Cycle (ORC) power systems for distributed power, waste heat recovery, and high efficiency applications using combustible fuels.

HAOMIN YUAN

Haomin Yuan is currently a graduate student major in Nuclear Engineering at University of Wisconsin-Madison. He got his bachelor degree in Tsinghua University, Beijing, also in Nuclear Engineering. In his undergrad, he did some research about coupling neutron transport code and CFD code for pebble bed reactor. In his current study, he focuses on CFD simulation of supercritical carbon dioxide flow in labyrinth seals and valves.



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