

Workshop on Understanding Cyclic Variability in Internal Combustion Engines

Hosted by

The Virtual Engine Research Institute and Fuels Initiative (VERIFI)

Advanced Photon Source (APS) Lower Gallery, Argonne National Laboratory

November 7–8, 2017

Tuesday, November 7, 2017

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| 7:00-8:00 a.m. | Registration |
| 8:00-8:05 a.m. | John Quintana: Deputy Laboratory Director for Operations
Welcome to Argonne National Laboratory |
| 8:05-8:15 a.m. | Ann Schlenker: Director Center for Transportation Research
VERIFI at Argonne National Laboratory |
| 8:15-8:30 a.m. | Sibendu Som: Group Leader at Argonne National Laboratory
Workshop Objectives and Mechanics |
| 8:30-9:00 a.m. | Michael Weismiller: Program Manager at US DOE
The Importance of Cyclic Variability in Engines – the DOE Perspective |
| 9:00-9:45 a.m. | Ronald Reese: Senior Technical Fellow at FCA USA LLC.
Birth of an Engine - Conception to Delivery |
| 9:45-10:15 a.m. | Coffee break |
| 10:15-10:45 a.m. | Magnus Sjoberg: Principal Member of Technical Staff at SNL
Mitigation of Cycle-to-Cycle Combustion Variability to Enable Highly Efficient DISI Engines |
| 10:45-11:15 a.m. | Dave Reuss: Research Scientist at University of Michigan
Causal Analysis of SI Engine Combustion CCV Using Measurements and Simulations |
| 11:15-11:45 a.m. | Benjamin Boehm: Research Group Leader at Technical University Darmstadt
Investigating Chains of Cause and Effect: The Three-Dimensional In-Cylinder Flow and Cycle-to-Cycle Variations |
| 11:45 a.m.-1:00 p.m. | Sponsored Lunch |
| 1:00-2:00 p.m. | Tour of the Advanced Photon Source |
| 2:00-2:30 p.m. | Brian Kaul: Research & Development Staff at ORNL
Deterministic Cyclic Variability: Characterization and Control |
| 2:30-3:00 p.m. | Charles Finney: Research & Development Staff at ORNL
Deterministic Cyclic Variability: Modeling and Simulation |

- 3:00-3:30 p.m. David Hung, Professor at University of Michigan-Shanghai Jiao Tong University
Joint Institute Shanghai Jiao Tong University
Outlier Detection and Cyclic Variability Quantification of Planar In-cylinder Velocity Flow Fields
- 3:30-4:00 p.m. Coffee break
- 4:00-4:30 p.m. Tony Willcox: Director, Controls & Simulation at Pinnacle Engines, Inc.
Test and Simulation Results for Dilution Tolerance Extension on Pinnacle's Ultra-Lean LTC Opposed Piston Sleeve-Valve Engine
- 4:30-5:00 p.m. Eric Lendormy: Senior Thermofluids and Simulation Expert at Wärtsilä Corp.
Cyclic Variations in Medium Speed Engines: Toeing the Issue
- 5:00-5:30 p.m. Chris Powell: Principal Research Scientist at ANL
Experimental and Computational Effort to Capture Shot-To-Shot Variability in Diesel Injection
- 6:00-7:00 p.m. Sponsored Reception and poster session by Argonne researchers (Guest House)
- 7:15-8:30 p.m. Sponsored Dinner (Guest House)

Wednesday, November 8, 2017

- 7:30-8:00 a.m. Registration
- 8:00-8:30 a.m. Dan Haworth: Professor of Mechanical Engineering at Penn State University
In-Cylinder LES: A Historical Perspective
- 8:30-9:00 a.m. Christian Angelberger: Expert Engine Combustion Modeling at IFP Energies Nouvelles
Applying LES to Understand Non-Cyclic Engine Combustion Phenomena
- 9:00-9:30 a.m. Federico Millo: Full Professor at Politecnico di Torino
Modelling CCV and Knock in Downsized Turbocharged SI Engines
- 9:30-10:00 a.m. *Coffee break*
- 10:00-10:30 a.m. Seunghwan Keum, Staff Researcher at GM R&D
Industry perspective on cycle to cycle variation in IC engines
- 10:30-11:00 a.m. Keith Richards: President and Co-owner of Convergent Science Inc.
Predicting Cyclic Variability in an IC Engine Using a RANS Turbulence Model
- 11:00-11:30 a.m. Stefano Fontanesi: Professor at University of Modena at Reggio Emilia
Understanding the Origin of Engine CCV via LES: Strengths, Weaknesses and Needs
- 11:30 a.m.-Noon Michele Battistoni: Professor at University of Perugia

Multi-Cycle Simulations of Fuel and Water Injection Strategies with Knock Occurrence

Noon-1:00 p.m.	Sponsored Lunch
1:00-1:30 p.m.	Muhsin Ameen: Mechanical Engineer at ANL Numerical Prediction of CCV using the Parallel Perturbation Model
1:30-2:00 p.m.	Saumil Patel: Postdoc Researcher at ANL A Low-Mach, Spectral Element Simulation of the TCC-3 Engine
2:00-2:30 p.m.	Noah Van Dam: Postdoc Researcher at ANL Simulations of Flow, Spark and Combustion Variability in an Optically Accessible DISI Engine
2:30-3:00 p.m.	Janardhan Kodavasal: Mechanical Engineer at ANL Insights into Cyclic Variability using Machine Learning
3:00-3:30 p.m.	Riccardo Scarcelli: Research Engineer at ANL GDI Combustion Work at Argonne: The Impact of Ignition Characteristics on Combustion Stability under Lean and EGR Dilute Operation
3:30-3:35 p.m.	Doug Longman: Section Manager at Argonne National Laboratory Thank You
3:45-5:45 p.m.	Two parallel sessions, i.e., “Tours” and “One-on-One” Two tours for everyone (buses leave from the APS Auditorium) <ul style="list-style-type: none">• Engine facilities and Rapid Compression Machine• Argonne Leadership Computing Facility and Visualization Lab Each stop takes about 35-40 minutes, Buses back to the Guest House “One-on-One” (The VERIFI team will email room information to individuals who signed up for this session)

Tour Descriptions

Engine Facilities and Rapid Compression Machine

Argonne’s engine testing capability spans from light duty to heavy duty, with engines ranging in size from 0.5L up to 19L. Argonne’s facilities include state-of-the-art instrumentation for in-cylinder visualization and regulated and un-regulated emissions characterization (gaseous and particulate). These experiments generate high-quality data for validation of VERIFI simulations. Argonne is also the only national laboratory with a rapid-compression machine for generating very controlled, engine-like conditions for studying fuel ignition and combustion properties.

Advanced Photon Source

The Advanced Photon Source (APS) is a user facility at Argonne, which produces the brightest x-ray beams in the Western hemisphere, enabling multi-disciplinary research that advances science. A

dedicated hutch at APS allows VERIFI researchers to gain fundamental understanding of fuel injection and spray phenomena (such as cavitation and jet interactions) and aid advanced model developments.

Argonne Leadership Computing Facility

The Argonne Leadership Computing Facility is a user facility at Argonne that provides the computational science community with a world-class computing capability dedicated to breakthrough science and engineering. The tour will include a visit to Argonne's 10-petaflop MIRA supercomputer. The VERIFI team uses these facilities and collaborates extensively with ALCF scientists to scale up engine calculations.

One-on-One Session

VERIFI experts will be available for discussions with industry representatives to understand their computing needs and provide guidance on how VERIFI projects could help them design and optimize next-generation engines and fuels. Argonne will provide a list of VERIFI experts available for discussion.