Mitigating Gasoline Particulate Emissions: Challenges and Best Practices, a modeling and control perspective
Workshop

1-3 pm (EDT)
October 4th, 2020

Organizers: Simona Onori* and Mark Hoffman**
*Assistant Professor, Energy Resources Engineering, Stanford University
**Assistant Professor, Mechanical Engineering, Auburn University

Scope

Impending particulate emissions regulations have placed emphasis on the number of particles emitted from gasoline engines, creating an imposing challenge for manufacturers who utilize direct injection combustion strategies. While substantial work remains in the in-cylinder prevention of gasoline particulates, the immediate need remains their removal from current exhaust streams. Filtration of gasoline particulates creates unique challenges due to the inherent nature of spark ignited engine operation. This workshop outlines and addresses the fundamental modeling and control challenges of filtering gasoline particulates, provides best practices for experimental particulate investigations, introduces the audience to the unique challenges of physically modeling gasoline particulate filters, and speaks toward the impact of particulate filtration on engine control.

Speakers

Harikesh Arunachalam - harunachalam@rivian.com, Battery Algorithm Engineer, Rivian Automotive LLC

Mark Hoffman - mah0142@auburn.edu, Assistant Professor, Auburn University

Ameya Joshi - joshia@corning.com, Director, Emerging Technologies & Regulations Environmental Technologies, Corning Inc.

Svyatoslav (*Slava) Korneev* - svyatoslav.korneev@gmail.com , Research Scientist at PARC, a Xerox Company

Simona Onori - sonori@stanford.edu, Assistant Professor, Stanford University

Gabriele Pozzato - gpozzato@stanford.edu, Postdoctoral Fellow, Stanford University

Agenda

1:00 – 1:15	**Simona Onori**, Introduction
1:15 – 1:35	**Ameya Joshi,** "Review of Vehicle Engine Efficiency and Emissions"
1:35 – 1:55	**Mark Hoffman,** "Experimental Investigations for Catalyzed GPF Model Development"
1:55 – 2:10	**Harikesh Arunachalam**, "Modeling the dynamics of Gasoline Particulate Filters for On-board Vehicle Emission Reduction"
2:10 – 2:25	**Gabriele Pozzato**, "Multi-channel physics-based modeling of GPFs using COMSOL Multiphysics"
2:25 – 2:45	**Slava Korneev**, "Multiscale modeling of the transport dynamics in gasoline particulate filters"
2:45 – 3:00	Discussion and workshop wrap-up

Reading Material

1. Joshi, A., "Review of Vehicle Engine Efficiency and Emissions," *SAE Technical Paper* 2020-01-0352, 2020

2. Joshi A., "Review of vehicle engine efficiency and emissions", *SAE Tech Paper* 2019-01-0314 2019

3. Joshi A., Johnson TV, "Gasoline particulate filters—a review", *Emission Control Science and Technology*, 4, p. 219–39, 2018

4. Korneev, S., Onori, S., "Modeling the Flow and Transport Dynamics in Gasoline Particulate Filters to Improve Filtration Efficiency", *J. Dyn. Sys., Meas., Control.* Jun 2020, 142(6) https://doi.org/10.1115/1.4046151

5. Arunachalam, H., Pozzato, G., Hoffman, M., Onori, S., "Modeling the thermal and soot oxidation dynamics inside a ceria-coated gasoline particulate filter," *Control Engineering Practice*, Vol. 94 Jan. 2020

6. Takahashi, A., Korneev, S., Onori, S. "Sensitivity Study on Thermal and Soot Oxidation Dynamics of Gasoline Particulate Filters", *2019 SAE World Congress*, Detroit, MI, April 10-12, *SAE Tech Paper* 2019-01-0990

7. Rathod, D., Filipi, Z., Onori, S., and Hoffman, M. A., "Experimental Investigation of Soot Accumulation and Regeneration in a Catalyzed Gasoline Particulate Flter utilizing Particulate Quantification and Gas Speciation Measurements", *2018 ASME Internal Combustion Fall Technical Conference*, San Diego, CA, Nov. 4-7, 2018 - **Awarded "MOST VALUABLE TECHNICAL PAPER IN TRACK 2 - EMISSIONS CONTROL SYSTEMS" by the Internal Combustion Engine Division**

8. Moser, S., Onori, S., and Hoffman, M. A., "Design and Experimental Validation of a Spatially Discretized, Control-Oriented Temperature Model for a Ceria-Washcoated Gasoline Particulate Filter", *2018 ASME Internal Combustion Fall Technical Conference*, San Diego, CA, Nov. 4-7, 2018

9. Korneev, S., Onori, S., Modeling the Transport Dynamics in Gasoline Particulate Filters, Proceedings of the *ASME 2018 Dynamic Systems and Control Conference*, Atlanta, GA, Sept 30 - Oct 3, 2018

10. Arunachalam, H., Pozzato, G., Hoffman, M., Onori. S., "Modeling the thermal dynamics inside a ceria-coated Gasoline Particulate Filter", *IEEE Conference on Control Technology and Applications*, Kohala Coast, Hawai'i, USA, August 27-30, 2017 - **Best Student Paper Award**

11. Pozzato, G., Hoffman, M., Onori, S., "Multi-channel physics-based modeling and experimental validation of an uncoated Gasoline Particulate Filter in clean operating conditions", *2017 American Control Conference, Seattle*, WA, May 24-26, 2017

Biographies

Harikesh Arunachalam received the B.E. degree in mechanical engineering from the Birla Institute of Technology and Science, Pilani, India, in 2010, the M.S. degree in mechanical engineering from the University of California, San Diego, CA, USA, in 2011, and the Ph.D. degree in automotive engineering from Clemson University, SC, USA, in 2017. He is currently working as a battery algorithm engineer at Rivian Automotive LLC, Irvine, CA, USA. His job duties involve development of on-board application layer software components for ensuring safe and reliable performance of the high voltage battery pack. His other research interests are multiscale modeling, parameter identification, experimental validation, and electrical-thermal modeling of lithium-ion batteries, PbA batteries, and supercapacitors, and modeling of the transport dynamics in engine exhaust after treatment systems such as gasoline particulate filters. He was a recipient of the Student Best Paper Award at the 2017 IEEE CCTA.

Dr. Mark Hoffman is an assistant professor of mechanical engineering at Auburn University where he teaches thermodynamics, heat transfer, and advanced powertrain systems. He has 18 years of expertise in kinetically controlled combustion, multi-fuel combustion, in-cylinder heat transfer, thermal barrier coatings, catalytic emission systems, particulate emissions characterization, waste heat recovery, and fuel-efficient vehicle platooning. Prior to his employment with Auburn, Hoffman was a research assistant professor at Clemson University's Department of Automotive Engineering where he also served as director for Clemson's Automotive Engineering Certificate program. Dr. Hoffman received his B.S. in Mechanical Engineering from Union College and both his M.S. and Ph.D. in mechanical engineering from the University of Michigan.

Dr. Ameya Joshi is the director of emerging technologies and regulations at Corning Incorporated, where he oversees following advances in powertrain, engine and emissions control technologies and regulations, with a focus on vehicular emissions in light-duty and heavy-duty sectors for the company's Environmental Technologies division. He provides credible technical guidance to engage regulators, customers and other automotive suppliers on the direction of emissions regulations globally and their impact on future technology choices. His previous roles at Corning include Technology Manager for Japan and Korea and Research Manager for the Modeling & Simulation group. Ameya currently serves as an associate editor for the SAE Journal of Engines and as Publishing Editor for the journal Emission Control Science and Technology. He is also a reviewer for various projects funded by the U.S. Department of Energy's Vehicle Technologies Office through the Annual Merit Review. He received his Ph.D. from the University of Delaware in Mechanical Engineering.

Svyatoslav Korneev's research interests focus on multiscale analytical and numerical methods for solid and fluid mechanics. Currently, he is working on developing a new upscaling technique that carries the important micro-scale information up to the macro-scale level in a computationally efficient fashion. This research can potentially result in an accurate reduced-order system of equations that model the process of advanced additive manufacturing. Svyatoslav's career in computational physics started in 2012 as a Ph.D. student in the Institute for Spectroscopy at the Russian Academy of Sciences. His program was focused on the theory of dark solitons and dispersive shock waves in Bose-Einstein Condensate (BEC) and nonlinear optics. After defending his Ph.D. thesis, he held a few postdoctoral positions. In November 2017, he joined Stanford University as a physical science research scientist.

Simona Onori is an Assistant Professor at Stanford University in Energy Resources Engineering where she also holds a courtesy appointment in EE and directs the Stanford Energy Control Lab (onorilab.stanford.edu). Prior to Stanford, she was an Assistant Professor at Clemson University-International Center for Automotive Research. Simona Onori received her Laurea Degree, summa cum laude in Electrical and Computer Engineering from University of Rome 'Tor Vergata', her M.S. in Electrical Engineering from the University of New Mexico, and her Ph.D. in Control Engineering from University of Rome 'Tor Vergata'. Her research is in sustainable transportation, emission reduction systems, clean energy and secondary life battery. She serves as the Editor-in-Chief of the SAE International Journal of Electrified Vehicles since 2020 and she is a Distinguished Lecturer of the IEEE Vehicular Technology Society for the 2020/22 term. She is the recipient of the 2019 Board of Trustees Award for Excellence, Clemson University, 2018 Global Innovation Contest Award, LG Chem, 2018 SAE Ralph R. Teetor Educational Award, 2017 NSF CAREER award.

Gabriele Pozzato was born in Vicenza, Italy, on October 31st, 1991. He received his Bachelor's degree in Information Engineering from Università di Padova and his Master of Science (cum laude) in Automation and Control Engineering from Politecnico di Milano. He was a visiting scholar at the Clemson University International Center for Automotive Research (CU-ICAR), South Carolina (USA), from January to November 2016. He received his Ph.D. in Information Technology from the Politecnico di Milano in 2020, defending a thesis on the optimization, modeling, and control of vehicles' powertrain. During his doctoral studies, he was an academic guest at the ETH Zürich and the Leibniz Universität Hannover. After the doctoral degree, he was project manager at Robert Bosch S.p.A., Sensortec division. He currently holds a post-doc position at the School of Earth, Energy & Environmental Sciences, Stanford University.

Workshop on

Controllable Tensegrity Structures and Membranes
ASME 2020 Dynamics Control Systems Conference

3-5 PM, October 4, 2020

Organizer and presenter: Professor Cornel Sultan, Virginia Tech, Blacksburg, VA, 24061,
csultan@vt.edu

Abstract: The growing need for lightweight, flexible, adaptive mechanical systems led to increased interest in structural networks which include a large number of cables. This approach to structural design leads to significant reduction in weight as well as increased flexibility compared to classical bar assemblies. Important members of the cable structures family are tensegrity structures, which are prestressed cable-bar networks that elicit significant interest from the dynamic and control community. These also have a bio-inspired flavor since they mimic the articulated skeletons of living organisms. In these organisms, tendons and muscles control the movement of the skeletal structure, playing the equivalent role of cables, while bones can be assimilated with bars in tensegrity. If membranes are added to these structures, they mimic the skin of living organisms. Importantly, recent advances in electronics, signal processing, control, as well as materials, computational capabilities and system design, enable implementation of modern controllers that can effectively control the behavior of such structures. Following these major breakthroughs, this workshop discussed key challenges, fundamental principles, and recent advances in the analysis, design, and control of tensegrity and membrane structures.

Outline

Session 1: Introduction and Motivation   **(15 min)**

What is "Tensegrity"? Why tensegrity and membranes in engineering? Opportunities: from buildings to relativistic micro-spacecraft. How can α Centauri be reached in 20 years (Breakthrough Starshot Initiative)?

Session 2: Fundamentals and Key Properties   **(35 min)**

Prestressability, mechanisms, dynamics. Stiffness, static, and dynamic stability. Particularities and computational advantages for prestressable structures. The interplay between mechanisms and natural modes in dynamic stability.

Session 3: Tensegrity Control and Deployment   **(30 min)**

Actuation and sensing elements. Large and small tensegrity motion control. Quasi-stationary deployment using slowly varying control theory. Fast and energy efficient deployment using tensegrity mechanisms.

Session 4: Tensegrity and Membranes Control   **(30 min)**

Membrane dynamics modeling for control. Tensegrity-membrane deployment and stabilization. Modern techniques (partial feedback linearization, linear parameter varying LPV) in tensegrity-membrane control.

Session 5: Closing remarks, Discussions   **(10 min)**

Cornel Sultan Biographical Sketch: Dr. Cornel Sultan received a Ph.D. in Aeronautics and Astronautics from Purdue University in 1999. Between 1999-2007 he was affiliated with a start-up company, Tensegra Inc. (1999-2001), Harvard Medical School (2001-2003), Scientific Systems Company Inc. (SSCI; 2001-2004), and United Technologies Research Center (UTRC; 2004-2007). At Tensegra and Harvard Medical School his work was focused on structural modeling and design for artificial spinal discs and the cytoskeleton of living cells. At SSCI and UTRC he worked primarily on formation flying spacecraft and helicopter modeling and control, including swashplateless and active rotor helicopters, heavy lift helicopters, fly-by-wire control design. He joined Virginia Tech's Aerospace and Ocean Engineering Department in 2007 where he is a Professor. His current research interests are in dynamics, control, and design, with applications to structures, energy harvesting systems, vehicles, and networks.

Session Title: Getting Funded by NSF: Proposal Preparation and the Merit Review Process

Sponsor: National Science Foundation

Organizers: Irina Dolinskaya

Speakers: Irina Dolinskaya

Abstract

So, you think you have a great research idea, now how do you get funding from the National Science Foundation (NSF) to do the work? A well-scoped and written proposal is instrumental to successful submission. This session targets junior faculty and researchers who might be new to NSF and describes detailed guidelines and practical advice for proposal preparation. The presenter will go over NSF review process and Intellectual Merit and Broader Impacts criteria, as well as share most common mistakes made by the Primary Investigators when submitting a proposal.   Question-and-answer session will follow the presentation.

Speaker Bio

Irina Dolinskaya is a Program Director at the National Science Foundation (NSF) in the Division of Civil, Mechanical & Manufacturing Innovation (CMMI). Dr. Dolinskaya services Dynamics, Control and Systems Diagnostics (DCSD) and Foundational Research in Robotics (Robotics) programs, as well as National Robotics Initiative (NRI 2.0) and Navigating the New Arctic (NNA) NSF's 10 Big Ideas. Prior to joining NSF, Irina Dolinskaya was a faculty in the Industrial Engineering and Management Sciences department at Northwestern University. She obtained M.S. and Ph.D. degrees in Industrial and Operations Engineering from the University of Michigan, and B.S. degree in Industrial Engineering from the University of Florida.

Dr. Irina Dolinskaya's research is in the field of transportation science and logistics with focus on adaptive modeling and solution approaches to integrate dynamic real-time information. Her current primary applications are in humanitarian logistics, optimal vessel performance, and electric vehicle routing. Irina Dolinskaya is the winner of the INFORMS Transportation Science & Logistics Society Dissertation Prize and the 2008 recipient of the Bonder Scholarship for Applied Operations Research in Military Applications.