

CHRISTOPHER L. HAGEN, PHD, PE

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RESEARCH: Energy systems, advanced internal combustion engines, unconventional fuels, control systems, optical sensors, applied thermodynamics, and fluid mechanics.

EDUCATION: **PhD, Mechanical Engineering** **University of Wisconsin-Madison, 2006**
Minor: Control Systems Madison, WI

Thesis topic: *Optical Measurements in Kinetically Controlled Combustion*

MS, Mechanical Engineering **Colorado State University, 2002**
Emphasis: Energy Conversion Fort Collins, CO

BS, Mechanical Engineering **Valparaiso University, 1997**
Minor: Manufacturing Management Valparaiso, IN

EXPERIENCE: **Assistant Professor** **July 2012 – present**
Oregon State University-Cascades ***Bend, OR***

Founder and director of the OSU Energy Systems Laboratory. Lead a team of ~10 undergraduate, graduate, postdoctoral and technician researchers investigating clean, novel energy conversion technologies while instructing Energy Systems Engineering (ESE) students in the thermal-fluid sciences.

Assistant Research Professor **March 2010 – July 2012**
Colorado State University ***Fort Collins, CO***

Conducting experiments and educational activities with regard to advanced power generation systems. Pursuits include assessing the operability of unconventional fuels such as both hydrotreated biofuels and biomass-derived low energy density gaseous fuels in combustion engines, field testing feedback control systems for stationary engine emissions control, and developing optical sensors for both fuel quality monitoring and quantification of trace combustion emissions in the troposphere.

Lead Fuels Research Engineer **December 2006 – March 2010**
Chevron Energy Technology Company ***Richmond, CA***

Developed and implemented fuel research programs to evaluate unconventional fuel performance in high efficiency gasoline and diesel engines. Technical and project manager of global programs with universities, national laboratories, contract laboratories, and industry partners.

Designed and constructed a >\$2 million 1000 SF single cylinder engine research facility, with advanced emission characterization equipment, capable of investigating combustion performance of both bio-derived and petroleum-derived fuels.

Graduate Research Assistant **August 2003 – December 2006**
University of Wisconsin Engine Research Center ***Madison, WI***

Developed novel laser-based sensors for collecting chemical kinetic information in harsh environments; specifically, absorption-based microsecond-resolution temperature and species concentrations measurements in n-heptane and isoctane-fueled homogenous charge compression ignition (HCCI) engines.

Application Engineer **February 2001 – August 2003**
Woodward Industrial Controls Inc. ***Fort Collins, CO***

Responsible for fuel delivery system development and analysis. Activities included: fuel system design, fuel flow analysis, component selection, and flow calculations.

Oversaw control system development of 400kW miniturbine generator set located at Walter Aircraft Engines, Prague, Czech Republic.

Onsite control system engineer for 30 MW natural gas fired turbine generator sets, Pratt & Whitney Power Systems, East Hartford, CT.

Engineer **December 1998 – December 2000**
Enginuity International Inc. ***Fort Collins, CO***

Primary test engineer for final engine set-up of large bore (> 35 cm) natural gas compression engine emissions reduction retrofit projects. Commissioned control systems with lean oxides of nitrogen (NO_x) reduction algorithms, high pressure fuel injection systems, precombustion chambers, high-energy multistrike ignition systems, and upgraded turbochargers.

Graduate Research Assistant **May 1997 – December 1998**
Colorado State University Engines and Energy Conversion Lab. ***Fort Collins, CO***

Project manager on Global Engines Laboratory online test cell, a web-based educational tool that allows the user to remotely run physical engine experiments. Project scope was three engine stands, fueled with gasoline, diesel, and natural gas respectively.

Co-op Engineer **May 1994 – August 1996**
Cincinnati Milacron Inc. ***Cincinnati, OH***

Assisted senior engineers in fabrication of high-speed gantry mill for fuselage machining.

TEACHING AND ADVISING:

Courses Taught

ME 311 Introduction to Thermal and Fluid Sciences, 2014, 2013, 2012
ME 312 Thermodynamics, 2014, 2013
ME 331 Introductory Fluid Mechanics, 2012
ME 505 Combustion, Reading and Conference, 2014
ME 599 Intermediate Thermodynamics, 2015 (in preparation)
MECH 337 (CSU) Thermodynamics, 2012
MECH 417 (CSU) Control Systems, 2010
Guest Lecturer; MECH 661 (CSU) Int. Comb. Eng., ME 770 (U. of WI) Adv. Exp. Instr.

Post-Doctoral Researchers

Dr. Shyam Menon
Dr. Kyle Niemeyer

Advisor, Graduate Students

PhD Himakar Ganti
PhD/MSME Shane Daly
MSME Robert Elgin III
MSME Zachary Taie
MSME Matthew Boley (CSU, 2012)

Member, Graduate Committee

PhDME Ida Truedsson (Faculty Opponent, Lund University, Sweden, 2014)
PhDME Thomas Mosier
MSME student Roshan Kochuparampil (CSU, 2013)

Advisor, Undergraduate Honors

BSME Sean Brown
BSME Torres Neuhoff (CSU, 2012)

Advisor, Undergraduate Researcher Students

BSESE James Malone
BSESE Nicholas Olson
BSESE Walter Beckwith
BSESE Zachary Taie
BSESE Josh Tibbitts, 2014
BSESE Dustin Stewart, 2013
BSESE Megan Glenn, 2013

Advisor, Senior Design Practicum

Academic Year (AY) 2014, AY 2013, AY 2011 (CSU), AY 2010 (CSU)

JOURNAL PUBLICATIONS

1. Bradley, T., Malakoutirad, M., **Hagen, C. L.**, Design Considerations for an Engine-integrated Reciprocating Natural Gas Compressor, *Applied Energy*, submitted.
2. **Hagen, C. L.**, Lee, B. C., Franka, I.S., Rath, J. L., VandenBoer, T. C., Roberts, J. M., S. S. Brown and Yalin, A. P., Cavity Ring-Down Spectroscopy Sensor for Detection of Hydrogen Chloride, *Atmospheric Measurement Techniques Discussions*, 6, 7217-7250, 2013.
3. Kranendonk, L. A., Caswell, A. W., **Hagen, C. L.**, Neuroth, C. T., Shouse, D. T., Gord, J. R., Sanders, S. T., Temperature Measurements in a Gas-Turbine-Combustor Sector Rig Using Swept-Wavelength Absorption Spectroscopy. *Journal of Propulsion and Power* 2009, 25 (4), 859-863.
4. **Hagen, C. L.**, Sanders, S. T., Investigation of Multi-Species (H₂O₂ and H₂O) Sensing and Thermometry in an HCCI Engine by Wavelength-Agile Absorption Spectroscopy. *Measurement Science & Technology* 2007, 18 (7), 1992-1998.
5. **Hagen, C. L.**, Sanders, S. T., Toward Hyperspectral Sensing in Practical Devices: Measurements of Fuel, H₂O and Gas Temperature in a Metal Homogeneous Charge Compression Ignition Engine. *Journal of Near Infrared Spectroscopy* 2007, 15 (4), 217-225.
6. **Hagen, C. L.**, Schmidt, J. R., Sanders, S. T., Spectroscopic Sensing via Dual-Clad Optical Fiber. *IEEE Sensors Journal* 2006, 6 (5), 1227-1231.
7. **Hagen, C. L.**, Walewski, J. W., Sanders, S. T., Generation of a Continuum Extending to the Midinfrared by Pumping ZBLAN Fiber with an Ultrafast 1550-nm Source. *IEEE Photonics Technology Letters* 2006, 18 (1-4), 91-93.
8. Walewski, J. W., Filipa, J. A., **Hagen, C. L.**, Sanders, S. T., Standard Single-Mode Fibers as Convenient Means for the Generation of Ultrafast High-Pulse-Energy Super-Continua. *Applied Physics B-Lasers and Optics* 2006, 83 (1), 75-79.

PEER REVIEWED CONFERENCE PROCEEDINGS

1. Niemeyer, K. E., Daly, S. R.; Cannella, W. J., **Hagen, C. L.** A Novel Fuel Performance Index for LTC Engines Based on Operating Envelopes in Light-Duty Driving Cycle Simulations, Proceedings of the *ASME Internal Combustion Engine Division Fall Technical Conference*, Columbus, Indiana, USA, 2014; Vol. ICEF2014-5478
2. Elgin, R. C., Daly, S., **Hagen, C. L.**, Experimental Validation Towards a Self-Refueling CNG Vehicle to Provide Home Refueling, *SAE 2014 World Congress*, Detroit, Michigan, USA, 2014; Vol. 2014-01-1343.
3. Echter, N. P., Weyer, K. M., Turner, C. W., Babbitt, G. R., **Hagen, C. L.**, Design and Analysis of a Self-Refueling CNG Vehicle to Provide Home Refueling, *SAE 2014 World Congress*, Detroit, Michigan, USA, 2014; Vol. 2014-01-1341.
4. Boley, M., **Hagen, C. L.**, Simulation of Turbocharged Marine Diesel Engine for Electrical Power System Trainer. In *ASME Internal Combustion Engine Division Spring Technical Conference*, ASME: Torino, Piemonte, Italy, May 2012.
5. Rath, J., Franka, I., Lee, B., **Hagen, C. L.**, Yalin, A., Cappelli, M., Electric Field Measurements in Gases Using Cavity Enhanced Polarimetry. In *AIAA Aerospace Sciences Meeting*, AIAA: Nashville, TN, January, 2012.
6. Zuehl, J. R., Ghandhi, J. B., **Hagen, C. L.**, Cannella, W. J., Fuel Effects on HCCI Combustion Using Negative Valve Overlap. In *SAE 2010 World Congress*, Detroit, Michigan, USA, 2010; Vol. 2010-01-0161.
7. **Hagen, C. L.**, Sanders, S. T., Application of a Novel White Laser Sensor to an HCCI Engine. In *SAE 2006 World Congress*, Detroit, Michigan, USA, 2006; Vol. 2006-01-1200.

CONFERENCE PROCEEDINGS, SELECTED PUBLICATIONS, & POSTERS

1. Niemeyer, K., Daly, S., Cannella, W.J., **Hagen, C.L.**, A New Fuel Index for LTC Engines Based on Operating Envelopes in Light-Duty Driving Cycle Simulations, W1P084, 35th Symposium on Combustion, San Francisco, California, USA, 2014, poster.
2. Taie, Z., **Hagen, C.L.**, Preventing Fuel Tank Oxygen Ingress for a Bimodal CNG Internal Combustion Engine, W1P134, 35th Symposium on Combustion, San Francisco, California, USA, 2014, poster.
3. Olson, N., **Hagen, C.L.**, Quantified Measurement of Droplet Evaporation Rates of a Two Component Mixture, W3P021, 35th Symposium on Combustion, San Francisco, California, USA, 2014, poster.
4. Niemeyer, K.E., Cannella, W.J., **Hagen, C. L.**, A New Fuel Index for LTC Engines Based on Operating Envelopes in Light-Duty Driving Cycle Simulations: Primary Reference Fuels, In *Western States Section of the Combustion Institute, Spring Technical Meeting*, Paper 14S-20, Pasadena, CA, USA, 2014.
5. Elgin, R. C., Turner, C. W., **Hagen, C. L.**, Combustion Chamber Design Considerations for a Compression Ignition Engine to Spark Ignited Natural Gas Engine Conversion. In *Western States Section of the Combustion Institute, Fall Technical Meeting*, Fort Collins, CO, USA, 2013.
6. **Hagen, C. L.**, NGV Self-Contained Home Filling Station. *ARPA-E MOVE Kickoff Meeting*, Washington, DC, December 2012.
7. Cannella, W. J. and **Hagen, C. L.** Fuels and Advanced Combustion Technology Research Activities, Chevron Global Downstream Technology Forum, Lafayette, California, USA, 2008, poster.
8. **Hagen, C. L.** Fundamentals of Transient Thermal-Light Absorption Spectroscopy and Application to Optical Sensing in HCCI Engines. University of Wisconsin-Madison, PhD Thesis, 2006.
9. **Hagen, C. L.** and Sanders, S. T. Multispecies Sensing with a Single Laser Source in HCCI Combustion, 31st Symposium on Combustion, Heidelberg, Germany, 2006, poster.
10. Kranendonk, L. A. , Caswell, A. W., **Hagen, C. L.**, Gord, J. R., Fujimoto, J. G., Sanders, S. T. Broadband, High-Resolution Absorption Spectroscopy in Piston and Gas Turbine Engines, Shock Tubes, and Rocket Plumes, 31st Symposium on Combustion, Heidelberg, Germany, 2006, poster.
11. Cherian, S., **Hagen, C. L.**, Kirkpatrick, A., Willson, B. The Global Engine Laboratory - Data Acquisition and Control Over the Internet. Proceedings, 9th Technology Based Engineering Education Consortium (TBEEC). Nashville, Tennessee, 1997.

SERVICE TO THE PROFESSION

- Session Organizer: 2015 SAE World Congress, Detroit, Michigan, USA, April 21 – 23, Combustion in Gaseous-Fueled Engines
- Reviewer, 2014, ASME Internal Combustion Engine Division Fall Technical Conference
- Session Organizer: 2014 SAE World Congress, Detroit, Michigan, USA, April 8 – 10, Compressed Natural Gas (CNG)/Dual-fuel CNG Engines
- Session Organizer: 2013 SAE World Congress, Detroit, Michigan, USA, April 16 – 18, Natural Gas Engines and Vehicles
- Reviewer, 2013, SAE International Powertrains, Fuels and Lubricants Meeting
- Reviewer, 2013, International Journal of Energy
- Reviewer (invited), 2013, Advanced Research Project Agency-Energy, Full Spectrum Optimized Conversion and Utilization of Sunlight (FOCUS) Full Applications
- Session Organizer: 2012 SAE International Powertrains, Fuels and Lubricants Meeting, Malmo, Sweden, September 18 – 20, Alternative and Advanced Fuels
- Session Organizer: 2012 SAE World Congress, Detroit, Michigan, USA, April 24 – 26, Fuel & Additive Effects on SI Engine Performance
- Session Organizer: 2010 SAE International Powertrains, Fuels and Lubricants Meeting, San Diego, California, USA, October 25-27, Alternative Fuels
- Session Organizer: 2009 SAE International Powertrains, Fuels and Lubricants Meeting, San Antonio, Texas, USA, November 2-4, Alternative Fuels

- Session Organizer: 2009 SAE International Powertrains, Fuels and Lubricants Meeting, Florence, Italy, June 15 – 17, Homogenous Charge Compression Ignition (HCCI), Variable Valve Actuation
- Reviewer: 2008 SAE International Powertrains, Fuels and Lubricants Meeting, Session: Alternative Fuels, Homogeneous Charge Compression Ignition Engines
- Reviewer: 2006 SAE World Congress, Session: Combustion and Flow Diagnostics
- Reviewer: 2006 SAE Small Engine Technology Conference
- Reviewer: Optics Communications Journal
- Reviewer: Measurement Science and Technology Journal

INVITED PRESENTATIONS

- Professional Engineers of Oregon, Annual Meeting, *Energy Conversion Research with an Eye towards Internal Combustion Engines and Natural Gas*, Wilsonville, Oregon, May 9, 2014.
- Oregon State University, Science Pub: *Natural Gas for Transportation*, Corvallis, OR, April 14, 2014.
- University of Alaska-Fairbanks, Alaska Center for Energy and Power (ACEP), *Energy Conversion with an Eye towards Internal Combustion Engines and Natural Gas*, Fairbanks, AK, December 2, 2013.
- Portland State University, Mechanical and Materials Engineering Department, *Energy Conversion with an Eye towards Internal Combustion Engines and Natural Gas*, Portland, OR, November 8, 2013.
- Professional Engineers of Oregon, Central Chapter Meeting, *Natural Gas Vehicle Research at OSU-Cascades*, Bend Oregon, April 22, 2013.
- Oregon State University, Science Pub: *Energy Research, What About Natural Gas for Transportation?*, Bend, OR, February 19, 2013
- MATHCOUNTS Middle School Students, *Engineering?*, Redmond, OR February 23, 2013.
- Rotary Club, Mt. Bachelor Chapter, *Energy Research, What About Natural Gas for Transportation?*, Bend, OR, December 14, 2012.
- Bend Research Incorporated, *Energy Research Areas: Getting More Out of What We Have*, Bend, OR, September 13, 2012.

SERVICE TO THE UNIVERSITY

- Graduate Council Representative, 2014, 2013
- Energy Systems Engineering Undergraduate Program Committee, 2014, 2013, 2012
- Mechanical, Industrial, and Manufacturing Engineering (MIME) School Head Search Committee, 2013
- MIME Thermal Fluid Science Faculty Search Committee, 2013, 2014
- Technical Advisor for OSU Advantage Accelerator Intern Program

PROPOSALS AWARDED AS PRINCIPAL INVESTIGATOR

- 2014 Gap Grant, Sponsor: Oregon Nanoscience and Microtechnologies Institute (ONAMI), \$250,000.
- 2014 Gap Grant, Sponsor: Oregon Built Environment & Sustainable Technologies (BEST), \$150,000.
- 2014 Advanced Research Project Agency for Energy (ARPA-E) Innovative Development in Energy-Related Applied Science (IDEAS), Sponsor: US Department of Energy, Award Number DE-AR0000485, \$500,000.
- 2013 Advanced Research Project Agency for Energy (ARPA-E) Methane Opportunities for Vehicular Energy (MOVE), Sponsor: US Department of Energy, Award Number DE-AR0000259, budget increase, \$299,900.
- 2013 Advanced Internal Combustion Engine Fuel Modeling and Testing, Energy Industry Sponsor, \$202,710.
- 2013 Gap Grant, Sponsor: OSU Venture Development Fund, \$25,000.
- 2013 Gap Grant, Sponsor: OSU Venture Development Fund, \$12,000.

- 2012 Advanced Research Project Agency for Energy (ARPA-E) Methane Opportunities for Vehicular Energy (MOVE), Sponsor: US Department of Energy, Award Number DE-AR0000259, \$699,392.
- 2011 University Design Challenge, Sponsor: Air Force Office of Scientific Research, \$60,000.
- 2010 Physics Based Dynamic Model of Marine Based Power Generation Equipment, Sponsor: Woodward Inc., \$71,000.
- 2009 Strategic Research proposal, topic confidential, Sponsor: Chevron Energy Technology Corporation, \$170,000 per annum.
- 2009 Strategic Research proposal, topic confidential, Sponsor: Chevron Energy Technology Corporation, \$80,000 per annum.
- 2004 Graduate Student author of “Dual-clad fiber optics for single-port absorption spectroscopy sensor,” Sponsor: The Optoelectronics Industry Development Association through the Photonics Technology Access Program (PTAP), \$33,000.

PATENTS

Hagen, C. L., G. Babbitt, C. Turner, N. Echter, K. Weyer-Geigel. “Internal Combustion Engine for Natural Gas Compressor Operation.” State of Oregon Acting by and through the State Board of Higher Education on Behalf of Oregon, assignee. U.S. Patent Application 14/244,807. Filed 3 Apr. 2014.

PROFESSIONAL MEMBERSHIPS, CERTIFICATIONS, AND AWARDS

Member, Society of Automotive Engineers (SAE)

Member, The Combustion Institute (Interim At-Large Western States Section Executive Committee member)

Member, American Society of Mechanical Engineering (ASME)

Member, Institute for Electrical and Electronics Engineers (IEEE)

Professional Engineer, State of Colorado

Scholarship, Association of Energy Engineers (AEE), 1998

ENTREPRENEURSHIP

Founder, OnBoard Dynamics Incorporated, October, 2013