

MICHAEL S. KLASSEN, Ph.D., P.E.

EDUCATION:

Ph.D., Mechanical Engineering, University of Maryland, 1992.

M.S., Mechanical Engineering, University of Maryland, 1990.

B.S., Mechanical Engineering, University of Maryland, 1987.

PROFESSIONAL EXPERIENCE:

Vice President and Principal Research Engineer, Combustion Science & Engineering, Inc., Columbia, MD, 1998 to present.

Responsible for the design and execution of experimental and analytical projects in fire and combustion research. Conduct fire and hazard investigations, including providing deposition and trial testimony. Provide engineering support for litigation cases. Conducted small-, medium- and large-scale testing on a variety of fire and smoke transport projects, including the transmission of radiation and breakage properties of glazing materials. Technical lead for gas turbine combustor design. Developed reduced chemical kinetic schemes for prediction of heat release and pollutant formation in gas turbine combustors. Developed analytical techniques for prediction of radiative loading in gas turbines for enhanced life predictions of liners.

Vice President and Chief Technical Officer, LPP Combustion LLC, Columbia, MD, 2007-present.

Developing and commercializing innovative technology for clean combustion of liquid fuels. Co-inventor of technology. Responsible for technical development of technology, working with staff of engineers to test, design and commercialize methodology and apparatus. Closely involved in business development, including company capitalization, organization and day-to-day operation.

Staff Engineer, Hughes Associates, Inc., Baltimore, MD, 1996-1997.

Designed and conducted experimental fire and combustion research. Involved in the testing and modeling of fire-suppression systems.

Visiting Asst. Professor/Postdoctoral Researcher, Purdue University, 1992- 1996.

Developed laser and optical diagnostic techniques for use in combustion applications. Utilized these techniques to investigate the formation of minor combustion species and pollutants in laminar and turbulent flames. Conducted experiments into the effect of pressure on nitric oxide (NO) formation in flames at pressures ranging from 1 to 15 atm. Local NO concentration measurements were made in laminar flames using laser-induced fluorescence (LIF) and used to evaluate the ability of current chemical kinetic mechanisms to predict NO formation in high-pressure flames. Instantaneous, local NO concentrations were also measured in premixed, turbulent jet flames which gave insights into the regions of NO formation in this type of flame and provided data for model validation. Further research involved the use of picosecond time-resolved laser-induced fluorescence (PITLIF) to determine instantaneous, quantitative concentration of minor species in turbulent flames. This study involved the application of ultra-fast spectroscopic techniques (resolution on the order of nanoseconds) in order to make time-series measurements of minor species concentrations in turbulent reacting flows. Lectured on introductory engineering thermodynamics.

Graduate Research Assistant, University of Maryland, 1989-1992.

Research involved the study of radiation properties and the flame structure of liquid-fuel pool flames. This work included measurements of the total radiative output, fuel burning rate and flame height for a variety of burner diameters (5 cm- 1 m). A new technique to measure radiative heat transfer from the flame to the fuel surface was developed. Instantaneous and simultaneous measurements of temperature, intensity and soot volume fraction were made using an optical pyrometric technique. Stochastic simulations using the measured instantaneous flame properties were employed for predictions of radiative output from the flame and the fuel burning rate.

Guest Researcher, National Institute of Standards and Technology, Center for Building and Fire Research, 1989 -1992.

Guest Researcher, Fire Research Institute, Department of Home Ministry, Tokyo, Japan, 1991.

Graduate Research Assistant, University of Maryland, 1988-1989.

Conducted research which investigated the transient cooling of hot surfaces by dropwise evaporation for use in fire suppression models. An infrared thermographic technique was developed to monitor the response of a heated low-conductivity surface to an impinging water droplet. Digital image processing techniques were utilized to extract the extent of cooling of the surface by the droplet and the transient surface temperature from the infrared data.

PROFESSIONAL REGISTRATION:

Registered Professional Engineer, Mechanical Engineering, License Number 23107 (Maryland).

PROFESSIONAL STANDING:

Member, The American Society of Mechanical Engineers

Member, The Combustion Institute

Member, AIAA

Member, Combustion and Fuels Committee, International Gas Turbine Institute

Member, NGC+ Work Group on Interchangeability

Point Contact, International Gas Turbine Institute (ASME) Combustion, Fuels and Emissions Committee (2013-2014)

HONORS:

Harry C. Bigglestone Award presented by *Fire Technology* (2007)

NFPA Harry C. Bigglestone Award for Excellence in Communication of Fire Protection Concepts, 2005.

PATENTS:

Eskin; L. D., Roby; R. J., Klassen; M. S., Ramotowski; M. J. "Integrated system and method for production and vaporization of liquid hydrocarbon fuels for combustion", US Patent 8,529,646, 2013.

Roby; R. J., Klassen; M. S., Schemel; C. F. "System for vaporization of liquid fuels for combustion and method of use", US Patent 8,225,611, 2012

Joklik; R. G., Roby; R. J., Klassen; M. S., Battaglioli; J. L., Hamer; A. J., Vashishat; D., "System and method for flame stabilization and control", US Patent 7,934,924, 2011.

Klassen, M., Gokulakrishnan, P., Fuller, C., Hamer, A., Ware, C., and Langdon, J., "System, Method and Apparatus for Hydrogen-Oxygen Burner in Downhole Steam Generator", US Patent 7770646, 2010.

Roby; R. J., Klassen; M. S., Schemel; C. F. "System for vaporization of liquid fuels for combustion and method of use", US Patent 7,770,396, 2010.

Roby, R., Klassen, M., and Schemel C., "System for vaporization of liquid fuels for combustion and method of use", U.S. Patent 7322198, 2008.

Joklik, R. G., Roby, R. J., Klassen, M. S., Battaglioli, J. L., Hamer, A. J., Vashishat, D., "System and Method for Flame Stabilization and Control", U.S. Patent No. 7,435,080, 2008.

Roby, R., Klassen, M., Eskin, L., Holton, M., and Straus, A., "Smoke alarm detector", U.S. Patent D545229, 2007.

Roby, R., Klassen, M., DuBois, J., Gaines, G., Ashley, E., "Method and apparatus for waking a person", U.S. Patent 7170397, 2007.

Roby, R., Klassen, M., and Schemel C., "System for vaporization of liquid fuels for combustion and method of use", U.S. Patent 7,089,745, 2006.

Roby, R., Klassen, M., Schemel, C., Vashishat, D., Holton, M., and Flint, K., "Method and apparatus for indicating activation of a smoke detector alarm", U.S. Patent 7015807, 2006.

SELECTED PUBLICATIONS:

Gokulakrishnan, P., Fuller, C. C., Klassen, M. S., Joklik, R. G., Kochar, Y. N., Vaden, S. N., Lieuwen, T. C. and Seitzman, J. M. (2014) "Experiments and Modeling of Propane Combustion with Vitiation" *Combustion and Flame*, Vol. 161; in press, DOI:10.1016/j.combustflame.2014.01.024.

Gokulakrishnan, P., Joklik, R., Viehe, D., Trettel, A., Gonzalez-Juez, E. and Klassen, M. (2014), "Optimization of Reduced Kinetic Models for Reactive Flow Simulations", *Journal of Engineering for Gas Turbines and Power*, Vol. 136, p. 011503-1.

Gokulakrishnan, P. and Klassen, M. S. (2013), "NO_x and CO Formation and Control," in *Gas Turbine Emissions*, T. Lieuwen and V. Yang, (Eds.) New York, NY: Cambridge University, pp. 175-208.

Gokulakrishnan, P., Joklik, R., Viehe, D., Trettel, A., Gonzalez-Juez, E., and Klassen, M., Optimization of Reduced Kinetic Models for Reactive Flow Simulations, 2013 ASME / IGTI Turbo Expo, San Antonio, TX, Paper # GT2013-95215, 2013.

Gokulakrishnan, P., Fuller, C. C., Joklik, R. G., and Klassen, M. S., "Chemical Kinetic Modeling of Ignition and Emissions from Natural Gas and LNG Fueled Gas Turbines", 2012 ASME / IGTI Turbo Expo, Copenhagen, Paper # GT2012-69902, 2012.

Holton, M.M., Gokulakrishnan, P., Klassen, M. S, Roby, R. J. (2010), "Autoignition Delay Time Measurements of Methane, Ethane, and Propane Pure Fuels and Methane-Based Fuel Blends", *Journal of Engineering for Gas Turbines and Power*, Vol. 132, pp. 091502-1-9.

Gokulakrishnan, P., Ramotowski, M. J., Gaines, G., Fuller, C., Joklik, R., Eskin, L. D., Klassen, M. S. and Roby, R. J. (2008), "A Novel Low NO_x Lean, Premixed, and Prevaporized Combustion System for Liquid Fuels", *Journal of Engineering for Gas Turbines and Power*, Vol. 130, pp. 051501:1-7.

Gokulakrishnan, P., Gaines, G., Currano, J., Klassen, M. S. and Roby, R. J. (2007), "Experimental and Kinetic Modeling of Kerosene-Type Fuels at Gas Turbine Operating Conditions", *Journal of Engineering for Gas Turbines and Power*, Vol. 129, pp. 655-663.

Zhang, W., Olenick, S.M., Klassen, M.S., Carpenter, D.J., Roby, R.J., and Torero, J.L., "A Smoke Detector Activation Algorithm for Large Eddy Simulation Fire Modeling," *Fire Safety Journal*, v.43, n.2, 2008.

- Ramotowski, M.J., Roby, R.J., Eskin, L.D., and Klassen, M.S., "Fuel Flexibility for Dry Low Emission Gas Turbines – Cleanly Burning Biofuels, Coal Liquids and Petroleum Fuels", PowerGen International, New Orleans, December 2007.
- Roby, R.J., Klassen, M.S., Eskin, L.D., Ramotowski, M.J., and Gaines, G.C., "Development of a System for Lean, Prevaporized, Premixed Combustion", presented at the 36th Turbomachinery Symposium, Houston, September 2007.
- Eskin, L.D., Roby, R.J., Klassen, M.S., and Ramotowski, M.J., "A Novel Approach for 'Clean' Power Generation Using Coal Liquids and the LPP Combustion Process in an Integrated Gasification Combined Cycle (IGCC) System", presented at the 24th Annual International Pittsburgh Coal Conference, Johannesburg, South Africa, September 2007.
- Gokulakrishnan, P., Ramotowski, M.J., Gaines, G., Fuller, C., Joklik, R., Eskin, L.D., Klassen, M.S., and Roby, R.J., "Experimental Study of NO_x Formation in Lean, Premixed, Prevaporized Combustion of Fuel Oils at Elevated Pressures", paper GT2007-27552, presented at the ASME Turbo Expo 2007: Power for Land, Sea and Air, Montreal, Canada, May 2007.
- Roby, R.J., Klassen, M.S., Eskin, L.D., and Ramotowski, M.J., "LPP Combustion – How to Burn Liquid Fuels as Cleanly as Natural Gas", presented at Electric Power 2007, Chicago, May 2007.
- Sutula, J., Klassen, M., Roby, R., Olenick, S., Gaines, G. and Torero, J., "Flame Extinction Based on a Critical Damköhler Number for the Assessment of Suppression Effectiveness in Reduced Gravity Environments," proceedings of the 5th International Seminar on Fire and Explosion Hazards, Edinburgh, Scotland, April 23-27, 2007.
- Olenick, S.M., Roby, R.J., Klassen, M.S., Zhang, W., Sutula, J.A., Worrell, C., Wu, D., D' Souza, V., Ashley, A., Dubois, J., Torero, J.L., and Streit, L., "The Role of Smoke Detectors in Forensic Fire Investigation and Reconstruction," Proceedings of the International Symposium on Fire Investigation Science and Technology (ISFI), 2006.
- Klassen, M. S.; Sutula, J. A.; Holton, M. M.; Roby, R. J.; Izbicki, T. Transmission Through and Breakage of Multi-Pane Glazing Due to Radiant Exposure, *Fire Tech.*, Vol. 42, No. 2, 79-107, 2006 .
- Olenick, S.M., Roby, R.J., Klassen, M.S., Zhang, W., Sutula, J.A., Worrell, C., Wu, D., D'Souza, V., Ashley, A., Dubois, J., Torero, J.L., and Streit, L., "The Role of Smoke Detectors in Forensic Fire Investigation and Reconstruction," Proceedings of the International Symposium on Fire Investigation Science and Technology (ISFI), 2006.
- Gokulakrishnan, P., Kwon, S., Hamer, A. J., Klassen, M. S., and Roby, R. J., "Reduced Kinetic Mechanism for Reactive Flow Simulation of Syngas/Methane Combustion at Gas Turbine Conditions", Submitted to GT2006, ASME Turbo Expo, Barcelona, Spain.
- Zhang, W., M.S. Klassen, and R.J. Roby, "Numerical Prediction of Smoke Detector Activation Accounting for Aerosol Characteristics," 8th International Symposium on Fire Safety Science, Beijing China, September 2005
- Ma. T., Olenick, S.M., Klassen, M.S., Roby, R.J., and Torero, J.L., "Carpet Under Fire: A Forensic View on the Role of Carpet (Porous Media) in Liquid Spill Fires", Harry C. Bigglestone Award Presentation, NFPA World Safety Conference and Exposition, Las Vegas, June, 2005.
- Gokulakrishnan, P., Klassen, M. S. and Roby, R. J. (2005), "Development of Detailed Kinetic Mechanism to Study Low Temperature Ignition Phenomenon of Kerosene", *Proceedings of IGTI*, ASME, Paper #GT2005-68268.

- Olenick, S.M., Zhang, W., Carpenter, D. J., Roby, R. J., and Klassen, S. M., "Verification and Validation of a Smoke Detector Activation Algorithm for the Fire Dynamics Simulator (FDS)", presented to the NFPA Fire Protection Research Foundation Fire Suppression and Detection Research Application Symposium, Orlando, January, 2005.
- Ma, T., Olenick, S. M., Klassen, M. S., Roby, R. J., and Torero, J. L., "Burning Rate of Liquid Fuel on Carpet (Porous Media)", *Fire Technology*, 40, 2004. (2005 Bigglestone Award)
- Roby, R.J., W. Zhang, G.C. Gaines, S.M. Olenick, M.S. Klassen, and J.L. Torero, "The Integration of a Smoke Detector Model with Large Eddy Simulation Fire Modeling for Predicting Smoke Detector Activation in Microgravity," Proceedings of Strategic Research to Enable NASA's Exploration Missions Conference and Workshop Poster Session, June, 2004.
- Klassen, M., Sutula, J., Holton, M., Roby, R., Izbicki, T., "The Evaluation of Life Safety Hazards Posed by Large Fires Outside Heavily Glazed Buildings," presented at the 2003 NFPA World Safety Conference & Exposition, Dallas, Texas, May 20, 2003.
- Zhang, W., M.S. Klassen, and R.J. Roby, "Turbulent Structure of the Flow Field in a One-Meter Diameter Methane Fire by Large Eddy Simulation," 3rd joint meeting of the U.S. Sections of the Combustion Institute, University of Illinois at Chicago, Chicago, Illinois, March 16-19, 2003.
- Zhang, W., A. Hamer, M. Klassen, D. Carpenter, R. Roby, "Turbulence statistics in a fire room model by large eddy simulation", *Fire Safety Journal* 37, 721-752, 2002.
- Ma, T., S. M. Olenick, M.S. Klassen, R.J. Roby and J. Torero, "Burning Rate of Liquid Fuel on Carpet (Porous Media)", submitted to the IAFSS 7th International Symposium of Fire Safety Science (2002).
- Stephen M. Olenick, Michael S. Klassen, and Richard J. Roby, "Validation Study of FDS for a High-Rack Storage Fire Involving Pool Chemicals," presented to the NFPA 430 (Storage of Liquid and Solid Oxidizers) Technical Task Group, January, 2002
- Holton, M.M., S.M. Olenick, M.S. Klassen, and R.J. Roby, "A Study of the Effectiveness of Passive Infrared Burglar Alarms to Detect Fires and Smoke," presented at NFPA's 6th *Fire Suppression & Detection Research Application Symposium*, Tampa, FL, January 2002.
- Zhang, W., A.J. Hamer, M.S. Klassen, D.J. Carpenter, and R.J. Roby, "Verification of the Turbulence Statistics for Fire Dynamic Simulator in a Room Fire," presented at 3rd Technical Symposium on Computer Applications in Fire Protection Engineering, Baltimore, MD, September 2001.
- Olenick, S.M., M.S. Klassen, and R.J. Roby, "Validation Study of FDS for a High-Rack Storage Fire Involving Pool Chemicals," presented at 3rd Technical Symposium on Computer Applications in Fire Protection Engineering, Baltimore, MD, September 2001.
- Zhang, W., A.J. Hamer, M.S. Klassen, D.J. Carpenter, and R.J. Roby, "Turbulence Statistics in a Fire Room Model By Large Eddy Simulation," presented at 2nd Joint Meeting of the U.S. Sections of the Combustion Institute, Oakland, CA, March 2001.
- Klassen, M. S., Sutula, J. A., Holton, M. M., Roby, R. J., and Izbicki, T., "Window Breakage of Multi-Pane Glazing due to Radiant Exposure," Proceedings of the *Fall Technical Meeting of the Eastern States Section of the Combustion Institute*, October 10-13, 1999.

- Hamer, A.J., Roby, R.J., and Klassen, M.S., "Comparison of Reduced Chemical Kinetics Mechanisms for Pollutant Emissions Predictions in Gas Turbines," presented at the ASME International Joint Power Generation Conference, Baltimore, MD, August 23-26, 1998.
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- Klassen, M. and J. P. Gore, "Temperature and Soot Volume Fraction Statistics in Toluene-Fired Pool Fires", *Combustion and Flame*, **93**, 270 - 278 (1993).
- Klassen M., J. P. Gore, A. Hamins, T. Kashiwagi, "Radiative Heat Feedback in a Toluene Pool Fire", *24th Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, 1713- 1719 (1992).
- Klassen, M., M. diMarzo, and J. Sirkis, "Infrared Thermography of Dropwise Evaporative Cooling", *Experimental Thermal and Fluid Science* **5**, 136-141 (1992).
- Klassen, M., J. P. Gore, and Y. R. Sivathanu, "Simultaneous Emission- Absorption Measurements in Toluene - Fueled Pool Flames: Mean and RMS Properties", *Combustion and Flame* **90**, 34 - 44 (1992).
- Hamins, A., M. Klassen, J. Gore, and T. Kashiwagi, "Estimate of Flame Radiance via a Single Location Measurement in Liquid Pool Flames", *Combustion and Flame* **86**, 223-228 (1991).
- Gore, J. P, M. Klassen, A. Hamins, and T. Kashiwagi, "Fuel Property Effects on Burning Rate and Radiative Transfer from Liquid Pool Flames", *Third International Symposium on Fire Safety Science*, Edinburgh, Scotland, 395 (1991).