Prof. Frederick L. Dryer

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Dr. Dryer received his Bachelor of Engineering Degree in Aeronautical Engineering from Rensselaer Polytechnic Institute, Troy, New York in 1966 and a Ph.D. degree in Aerospace and Mechanical Sciences from Princeton University, Princeton, New Jersey in 1972. He joined the Mechanical and Aerospace Engineering Department as a Professional Research Staff in 1972, the tenured academic faculty as an Associate Professor in 1981, and was promoted to Full Professor in 1983. He has served as the Undergraduate Departmental Representative from (1984-1987), and as Associate Dean of Academic Affairs for the School of Engineering and Applied Sciences (1987-1990).

His research contributions include: chemistry/chemical kinetics of fuels and hazardous waste materials as related to ignition, combustion, and emissions generation/abatement; the fundamentals of formation/ignition/secondary atomization/liquid phase chemistry of conventional and synthetic fuel droplets as related to heavy industrial fuel combustion/emission control, gas turbine/reciprocating engines and liquid fuel fire safety (on earth and in space environments); solid phase/gas phase interactions as related to particle burning phenomena and materials processing; hydrocarbon emissions from internal combustion engines, nitrogen oxides, aerosol particulates, and other pollutant interactions in high-performance gas turbines; and non-petroleum-derived alternative fuels, their production, their chemical kinetic properties, and their ability to address U.S. energy security and green house gas as well as other pollutant concerns.

Dr. Dryer has published extensively and consulted for the government, industry and legal profession on the above as well as other combustion, fire safety, energy, and emissions-abatement-related subjects. He is a former associate editor (eight years) and editorial board member (five years) of Combustion Science and Technology, co-editor for the Proceedings of the 26th and 27th International Symposiums on Combustion, a former editorial board member of the International Journal of Chemical Kinetics, and Progress in Energy and Combustion Science. Dr. Dryer has frequently served on advisory committees for industry and various government agencies, including the National Materials Advisory Board/National Research Council (five times), NASA, DOE, DARPA, ARO, and NIST. He is a member of the Combustion Institute, the American Institute of Aeronautics and Astronautics, the American Chemical Society, the American Society of Mechanical Engineers, the Society of Automotive Engineers (elected as a Fellow, 2003), the National Fire Protection Association.

Education

Ph.D. Aerospace and Mechanical Sciences - Princeton University, 1972
Bachelor of Aeronautical Engineering - Rensselaer Polytechnic Institute, 1966

Professional History

1983 -	Professor, Mechanical and Aerospace Engineering, Princeton University
Fall - 2001	Consulting Engineer (Sabbatical)
1996 - 1997	Consulting Engineer (Sabbatical)
1991 - 1992	Consulting Engineer (Sabbatical)
1987 - 1990	Associate Dean of Academic Affairs, School of Engineering and Applied Science
1984 - 1987	Undergraduate Departmental Representative, Mechanical and Aerospace Engineering
1982 - 1983	Consulting Scientist, Mobil Research and Development Corporation (Sabbatical)
1982 - 1983	Associate Professor, Mechanical and Aerospace Engineering, Princeton University
1977 - 1982	Lecturer, Mechanical and Aerospace Engineering, Princeton University
1976 - 1981	Research Engineer, Mechanical and Aerospace Engineering, Princeton University
1972 - 1976	Professional Research Staff Member of Guggenheim Laboratories for the Aerospace Propulsion Sciences, Princeton University
1971 - 1972	Research Associate, Princeton University

Professional Activities and Honors:

Professional Memberships:

The Societies of Sigma Gamma Tech, Sigma Xi, Tau Beta Pi, American Chemical Society, American Society of Automotive Engineers, American Society of Engineering Educators, American Society of Mechanical Engineers, The Combustion Institute.

Honors:

Society of Automotive Engineers Fellow, October, 2003

Silver Medal, 28th International Combustion Symposium, August, 2000.

Selection Panel, 1993 DLR Science Award, Deutsche Forschugsanstalt für Luft-und Raumfahrt e.V., 1993.

National Committee and Advisory Board Memberships:

Member National Materials Advisory Board/National Research Council Committee to Identify Needs to Foster Improved Fire Safety in the United States 2002-2003.

Member, Committee on Fire Safe Fuels for Aircraft, National Materials Advisory Board, Commission on Engineering and Technical Systems, National Research Council, 1996 - 1997.

Committee Member, Committee on Energy Conservation in the Processing of Industrial Materials, National Materials Advisory Board, Commission on Engineering and Technical Systems, National Research Council, 1990 -1993.

Member, NASA Scientific Advisory Panel on Atmospheric Effects of Aviation Project (AEAP), Earth Sciences and Applications Divisions, 1993 - 1995.

Chair, Engine Emissions Trace Chemistry Sub-Committee, NASA Atmospheric Advisory Panel on Atmospheric Effects of Stratospheric Aircraft (AESA), Earth Sciences and Applications Divisions, Office of Space Science and Applications, 1993 -95.

Member, National Academy of Sciences NRC Panel on Impacts of Diesel Powered Light Duty Vehicles, 1979-1980.

Member, National Academy of Sciences NRC Carbon Monoxide Control Assessment Panel, 1980.

Editorial Activities:

Editorial Board Member, Progress in Energy and Combustion Science, 2002-present.

Co-organizer, of the Droplets and Sprays Colloquium for the 29th International Symposium on Combustion, Sapporo, Japan, July 21-26, 2002.

Co-editor (and Co-chair, Publication Committee) 27th International Combustion Symposium Proceedings, Boulder CO, July 1998.

Editorial Board, International Journal of Chemical Kinetics, 1997 - 2002.

Co-editor (and Co-chair, Publication Committee) 26th International Combustion Symposium, The Combustion Institute, Pittsburgh, PA, 1996.

Associate Editor, Combustion Science and Technology, 1977-1986.

Editorial Board, Combustion Science and Technology, 1986 - 1991.

Review Activities:

Reviewer, ACS, ARO, DOE, NASA, NSF, ONR , NIST Technical Proposals.

Reviewer, Combust. Flame, Int. J. Chem. Kin., J.Phys. Chem., Combust. Sci. Tech., Enviro Sci. Tech., Int. J. Heat Transfer, AIAA, SAE, AICHE.

Selected Invitations:

Invited Speaker, 20th Italian National Heat Transfer Conference, Maratea, Italy. June 25 – 27, 2002.

Hottel Lecturer, Hottel Lecture Series on Energy and Combustion, Department of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, MA, 1991.

Invited Contributor, (with C.K. Westbrook), "Chemical Kinetics and Modeling of Combustion Processes", Invited Paper, *18th International Symposium on Combustion*, The Combustion Institute, Pittsburgh, PA, 1981, p. 749

Invited Contributor - "Water Addition to Practical Combustion Systems - Concepts and Applications", *16th International Symposium on Combustion*, The Combustion Institute, Pittsburgh, PA, 1977, p. 279.

Industrial Scientific Advisory Boards

Environmental Advisory Board, NetJets Inc., Woodbridge, NJ.

Science Advisory Board, Knite Corporation, Princeton, NJ.

Archival Publications, 2007 – Present

(with M. Chaos), “Syngas Combustion Kinetics and Applications”, in Special Issue: *Syngas Combustion* (V. Yang and T. Lieuwen, eds.). *Combustion Sci. Tech.* (2009). In Press.

(with Z. Zhao, M. Chaos, and A. Kazakov,), “Thermal Decomposition Reaction and a Comprehensive Kinetic Model of Dimethyl Ether”, *Int. J. Chem. Kin.* 40, 1-18 (2008).

(with M. Chaos), ”Ignition of Syngas/air and Hydrogen/air Mixtures at Low Temperatures and High Pressures: Experimental Data interpretation and Kinetic Modeling Implications, *Combust. Flame* 152, 293-299 (2008).

(with M. Chaos, A. Kazakov, and Z. Zhao), “A High Temperature Chemical-Kinetic Model for Primary Reference Fuels”, *Int. J. Chem. Kin.* 39, 399-414 (2007).

(with A. Yozgatligil, S-H. Park, M. Y. Choi, A. and Kazakov), “Influence of Oxygen Concentration on the Sooting Behavior of Ethanol Droplet Flames in Microgravity Conditions”, *Proc. Comb. Ins.* 31, 2165-1273 (2007).

(with S. Gaïl, M. Thomson, S. M. Sarathy, S. A. Syed, P. Dagaut, Pascal Diévart, and A. J. Marchese), “A Wide Range Kinetic Modeling Study of Methyl Butanoate Combustion”, *Proc. Comb. Ins.* 31, 305-311 (2007).

(with Z. Chen, X. Qin, Y. Ju, Z. Zhao, and M. Chaos), “High Temperature Ignition and Combustion Enhancement by Dimethyl Ether Addition to Methane-Air Flames”, *Proc. Comb. Ins.* 31, 1215-1222 (2007).

(with T. A. Cool, J. Wang, N. Hansen, P. R. Westmoreland, Z. Zhao, A. Kazakov, T. Kasper, and K. Kohse-Höinghaus), “Chemistry of Fuel-rich Dimethyl Ether Flames Using Combined Photoionization Molecular-Beam Mass Spectrometry and Modeling” *Proc. Comb. Ins.* 31, 285-293 (2007).

(with M. Chaos, Z. Zhao, J. N. Stein, J. Y. Alpert, and C. J. Homer), “Spontaneous Ignition of Pressurized Releases of Hydrogen and Natural Gas into Air”, *Combust. Sci. Tech.* 179, 1-31 2007).

(with J. Li, Z. Zhao, A. Kazakov, and M. Chaos), “A Comprehensive Kinetic Mechanism for CO, CH_2O, CH_3OH Combustion”, *Int. J. Chem. Kin.* 39, 109-136 (2007).

(with M. Chaos, A. Kazakov, and Z. Zhao), “Computational Singular Perturbation Analysis of Two Stage Ignition of Large Hydrocarbons”, *J. Phys. Chem. A.* 110, 7003-7009 (2006).

(with Z. Zhao, J. Li, A. Kazakov, and S. P. Zeppieri), “Burning Velocities of N-Decane a High Temperature Skeletal Kinetic Model For N-Decane-Air Mixtures”, *Combust Sci. Tech.* 177, 89-106 (2005).

(with M. Chaos, Z. Zhao, J. N. Stein, J. Y. Alpert, and C. J. Homer), “Spontaneous Ignition of Pressurized Releases of Hydrogen and Natural Gas into Air”, *Combust. Sci. Tech.* 179, 1-31 (2007).

Other Selected Recent Publications and Pre-prints

(with M. Chaos, Z. Zhao, A. Kazakov, P. Gokulakrishnan, and M. Angioletti), “A PRF+Toluene Surrogate Fuel Model for Simulating Gasoline Kinetics”, 5th US Combustion Meeting, University of California at San Diego, San Diego, CA, March 25-28, 2007. Paper E-26

(with M.P. Burke, X. Qin, and Y. Ju), “Measurements of Hydrogen Syngas Flame Speeds at Elevated Pressures”, 5th US Combustion Meeting, University of California at San Diego, San Diego, CA, March 25-28, 2007. Paper A-16.

(with J. Li, A. Kazakov, and M. Chaos), “Chemical Kinetics of Ethanol Oxidation”, 5th US Combustion Meeting, University of California at San Diego, San Diego, CA, March 25-28, 2007. Paper C-26.

(with J.T. Farrell, N.P. Cernansky, F.L. Dryer, D.G. Friend, C.A. Hergart, C. K. Law, R.M. McDavid, C.J. Mueller, A.K. Patel, and H. Pitsch), “Development of an Experimental Database and Kinetic Models for Surrogate Diesel Fuels”, *SAE paper 07PFL-676* (2007)

(with W. J. Pitz, N. P. Cernansky, F. N. Egolfopoulos, J.T. Farrell, D. G. Friend, H. Pitsch), "Development of an Experimental Database and Chemical Kinetic Models for Surrogate Gasoline Fuels", *SAE paper 2007-01-0175* (2007).

(with M. Colket, N.P. Cernansky, C. K. Law, F. Egolfopoulos, D. Friend, D. B. Lenhert, P. Lindstedt, H. Pitsch, A. Sarofim, K. Seshadri, M. Smooke, W. Tsang, S. Williams and T. Edwards), "Development of an Experimental Database and Kinetic Models for Surrogate Jet Fuels", AIAA Annual Conference, Reno NV, January, 2007.

(with M. Chaos, Z. Zhao, and A. Kazakov), "An Experimental and Kinetic Study of Acetone Oxidation in a Flow Reactor", Work in Progress Poster, 31st International Symposium on Combustion, University of Heidelberg, Germany, August 6-11 2006. Available at: http://www.princeton.edu/~combust/

(with M. Chaos, A. Kazakov, and Z. Zhao), "Model Development and Reduction Methods for High-temperature Large Alkane Molecule Kinetics" Work in Progress Poster, 31st International Symposium on Combustion, University of Heidelberg, Germany, August 6-11. Available at: http://www.princeton.edu/~combust/

(with Z. Zhao, J. Li, and A. Kazakov), "Temperature-Dependent Feature Sensitivity Analysis for Combustion Modeling**",** *Int. J. Chem. Kin.* 37, 282 (2005).

(with Z. Zhao, J. Li, A. Kazakov, and S. P. Zeppieri), "Burning Velocities of *n*-Decane a High Temperature Skeletal Kinetic Model For N-Decane-Air Mixtures", *Combust Sci. Tech.* 177, 89-106 (2005).

(with Z. Zhao, J. P. Conley, and A. Kazakov), "Burning Velocities of Real Gasoline Fuel at 353 K and 500 K", SAE Paper No. 2003-01-3265. *SAE Transactions 2004*.

(with J. Li, Z. Zhao, and A. Kazakov), "An Updated Comprehensive Kinetics Model of H_2 Combustion", *Int. J. Chem. Kin.* 36, 566 (2004).

(with J. Vican, B.F. Gajdeczko, D. L. Milius, I. A. Aksay, and R.A. Yetter), "Development of a Microreactor as a Thermal Source for MEMS Power Generation", *Proc Int. Comb. Ins.* 29, 909-916 (2002).

(with M.Y. Choi), "Microgravity Droplet Combustion" *Microgravity Combustion, Fire in Free-Fall*, H.D. Ross, ed., Academic Press, NY, NY, 2001. pp. 183-298.

(with R.A. Yetter), "Metal Particle Combustion and Classification" *Microgravity Combustion, Fire in Free-Fall*, H.D. Ross, ed., Academic Press, NY, NY, 2001. pp. 419-478.

(with J.A. Eng, W.R. Leppard, and P.M. Najt), "The Interaction Between Nitric Oxide and Hydrocarbon Oxidation chemistry in a spark Ignition Engine", *SAE Transactions 1998*.

(with T. Amano), "Effect of Dimethyl Ether, NOx, and Ethane on CH_4 Oxidation; High Pressure, Intermediate Temperature Experiments and Modeling", *27th Symposium (Intn'l) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1998. p. 397.

(with P. Bucher, R.A. Yetter, T.P. Parr, and D.M. Hanson-Parr), "Flame Structure of Aluminum Particle Combustion in O_2, CO_2 and N_2O Oxidizers", *27th Symposium (Intn'l) on Combustion*, The Combustion Institute, Pittsburgh, PA., 1998. P. 2421.

(with T.J. Held), "A Comprehensive Mechanism for Methanol Oxidation", *Int. J. Chem. Kin.* 30, 805 (1998).

(with M.T. Allen and R.A. Yetter), "Hydrogen/Nitrous Oxide Kinetics - Implications of the N_xH_y Species", *Combust. and Flame* 112, 302, (1998).

(with R.A. Yetter, H. Rabitz, R.C. Brown and C.E. Kolb), “Effect of Fluorine on the Gasification Rate of Liquid Boron Oxide Droplets”, *Combust. and Flame* 112, 387 (1998).

(with R.A. Yetter and, M.T. Allen), “Gas-Phase Reaction Mechanisms for Nitramine Combustion: On the Development of a Comprehensive Reaction Mechanism for Hydrogen/Nitrous Oxide Kinetics”, in *Challenges in Propellants and Combustion 100 Years after Nobel*, (K. Kuo, ed.) Begell House, Inc. (1997).

(with M.T. Allen and R.A. Yetter), “High Pressure Studies of Moist Carbon Monoxide/Nitrous Oxide Kinetics”, *Combust. and Flame* 109, 449 (1997).

(with J.F. Roesler, and R.A. Yetter), "Inhibition and Oxidation Characteristics of Chloromethanes in the Presence of Moist Carbon Monoxide Oxidation", *Combust. Sci. and Tech.* 120, 11 (1997).

(with N.R. Purzer, R.A. Yetter and R.J. Lawson), "Fluidized Bed Studies of Carbon Particle Oxidation: Gas Phase Surface Products and Surface Area Evolution", *Combust. Sci. Tech.* 110-111, 147 (1996).

(with D.L. Urban and S.P. Huey), "Evaluation of the Coke Formation Potential of Residual Oils", *24th Symposium (Int.) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1992. p. 1357.

Graduate Students Advised Since 1990

J. Heyne, PhD candidate, 2009 – present; M. Haas, Ph. D. Candidate, 2006-present; M. Burke, Ph.D. candidate, 2005-present; J. Conley, M.S.E. candidate, in abstensia; B. Urban, Ph.D. candidate, in abstensia; K. Kroenlein, Ph.D., 2007; Z-W Zhao, Ph.D., 2005; J. Li, Ph.D., 2004; P. Ricklin, M.S.E., 2002; J. Scire, Ph.D., 2002; Z-W Zhou, M.S.E. 2002; L. Ernst, M.S.E., 2001; M. Mueller, Ph.D., 2000; S. Fischer, M.S.E., 1998;P. Bucher, Ph.D., 1998; J. Eng, Ph.D., 1998; W. Zhou, Ph.D., 1998; J. Gatto, M.S.E., 1997; D. Zarubiack, M.S.E., 1997; J.M. Fielding, M.S.E., 1997; A.J. Marchese, Ph.D., 1996; J.C.Y. Lee, Ph.D., 1996; C. Callahan, MSE, 1995; M. Allen, Ph.D., 1995; N. Ilincic, M.S.E., 1995; J. Roesler, Ph.D., 1994; T. Kim, M.S.E., 1994; T. Held, Ph.D., 1993; S. Kowalski, MSE, 1993; S. Huey, M.S.E., 1991; M.Y. Choi, Ph.D., 1991; M.L. Vermeersch, Ph.D., 1991; S. Hochgreb, Ph.D., 1991; G.T. Linteris, Ph.D., 1990; T.S. Norton, Ph.D., 1990.

Sponsored Postdoctoral Scholars

T. Farouk, Z. Yang, H. Xu, M. Chaos, Z. Zhao, M. Angioletti, A. Kozakov, S. Zeppieri, S. Klotz, S. Gurin, K. Southerland, D. Urban, S.Y. Cho, C. Corre, F. Takahashi, I.M. Kennedy.

Thesis Degreed Graduate Students

Since 1981: 39 Graduate Students; **Co-advised (with I. Glassman) Prior to 1981:** 8

Patents

(with G.J. Green, and D.E. Walsh), "Droplet Generation Apparatus", European Patent No. 85302157.4-, May 20, 1985; U.S. Patent No. 4,819,831 April 11, 1989. Assigned to Mobil Oil Corporation, N.Y. NY.