

# CHEMICAL AND PHYSICAL PROCESSES IN COMBUSTION



## 1980 TECHNICAL MEETING

The Eastern Section of The Combustion Institute  
November 12-14, Princeton, New Jersey

Co-Hosted by:

Exxon Research and Engineering Company, Linden, New Jersey  
and  
Princeton University, Princeton, New Jersey



Eastern Section of The Combustion Institute  
1980 Fall Technical Meeting  
November 12, 13 and 14, 1980  
Princeton University, Princeton, N. J.

Tuesday, November 11, 1980

7:30 p.m.-10:00 p.m. - Registration (Main Lobby, Nassau Inn)

Wednesday, November 12, 1980

7:30 a.m. - Registration (Engineering Quadrangle)

8:45 a.m. - Welcome and Introductory Remarks

Session A-1

Chairperson: Dr. W. Bartok  
Exxon Research and Engineering Company

ENERGY CONVERSION

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| 9:00 a.m.  | 1. "Refinery Vehicle Energy Balance: The Fuel Economy Outlook," W. J. Most and H. F. Shannon, Exxon Research and Engineering Company. (Invited Paper)  |
| 9:45 a.m.  | Break  |
| 9:50 a.m.  | 2. "Wood Combustion in a Swirl Burner," K. Annamalai and D. B. Stickler, Avco Everett Research Laboratory, Inc.  |
| 10:10 a.m. | 3. "Velocity Measurements in a Swirl-Stabilized Combustor," S. L. Lee and F. C. Gouldin, Cornell University.   |
| 10:30 a.m. | Coffee Break   |
| 11:00 a.m. | 4. "Preliminary Studies in the Pyrolysis of Biomass," W. R. Arthur, R. T. Gibbs and P. Durbetaki, Georgia Institute of Technology.   |
| 11:20 a.m. | 5. "A Comparative Study of the Burning Characteristics of Coal, Graphite, Coke, and Solvent Refined Coal in a Laboratory Burner," R. F. Sawyer and W. K. Chin, University of California, Berkeley. |
| 11:40 a.m. | 6. "The Combustion of Carbon Slurry Fuel -- Experimental Results," M. Lavid and L. A. Ruth, Exxon Research and Engineering Company.  |
| 12:00 p.m. | 7. "Low-Low Btu Gas Combustion," P. F. Lewis, Physical Sciences, Inc.  |
| 12:20 p.m. | Lunch Break  |



Session A-2  
Chairperson: Dr. D. J. Seery  
United Technologies Research Center

#### POLLUTION

- 2:00 p.m. 8. "Toxicology of Combustion Products,"  
M. Birky, National Bureau of Standards.  
(Invited Paper)
- 2:45 p.m. Break
- 2:50 p.m. 9. "A Comparison of Polycyclic Aromatic Hydro-  
carbons in Soot Produced from Various Sources,"  
D. B. Olson and H. F. Calcote, AeroChem  
Research Laboratories, Inc.
- 3:10 p.m. 10. "Combustion of and Sulfur Dioxide Removal from  
Coal/Oil/Water Emulsions in a 350 hp Firetube  
Furnace," J. P. Doohar, B. J. Gilmartin, R. W.  
Genberg, S. Moon, D. Albert, D. Wright,  
S. Jakatt, G. Carbone, T. Kanabrocki,  
C. Denauski, N. Chuisano, Adelphia Research  
Center, Inc.
- 3:30 p.m. Coffee Break
- 4:00 p.m. 11. "NO<sub>x</sub> Reduction by Fuel Rich NH<sub>3</sub> Injection,"  
P. F. Lewis and G. Kothandaraman Physical  
Sciences, Inc., T. Brogan, MEPPSCO, Inc.,  
D. M. Johnson, F. M. Stevens, Hazen Research,  
Inc.
- 4:20 p.m. 12. "Relationship Between Fuel-Nitrogen-to-NO<sub>x</sub>  
Conversion Efficiency and Boiling Range for  
Coal-Derived Liquid Fuel Combustion," O. L.  
Ogunsola and J. J. Reuther, The Pennsylvania  
State University.
- 4:40 p.m. 13. "Studies of Oxygenate Formulation in a Precom-  
bustion Flow Reactor," F. T. Hsieh, N. P.  
Cernansky and C. W. Savery, Drexel University

5:30 p.m. EXECUTIVE BOARD MEETING

Session B-1  
Chairperson: Professor G. M. Faeth  
The Pennsylvania State University

#### DROPLET AND SPRAY COMBUSTION

- 9:50 a.m. 39. "Effect of Thermal Radiation on the Droplet Pre-  
Evaporation in Spray Combustion," S-C Yao and  
N. Ashgrizzadeh, Carnegie-Mellon University.

- 10:10 a.m. 40. "The Boundary Layer Structure of a Vaporizing  
Cloud," S. M. Correa, M. Sichel and C. W.  
Kauffman, The University of Michigan.

10:30 a.m. Coffee Break

- 11:00 a.m. 41. "Effect of Fuel Droplet Composition on Ignition  
and Combustion Times," J. J. Sangiovanni,  
United Technologies Research Center

- 11:20 a.m. 42. "Observations of Vaporizing Water-in-Fuel  
Emulsion Droplets," S. A. Sheffield, M. R.  
Baer and G. J. Denison, Sandia National  
Laboratories.

- 11:40 a.m. 43. "Circulation and Coalescence Within a Vaporizing  
Emulsified Fuel Droplet," M. R. Baer, S. A.  
Sheffield and G. J. Denison, Sandia National  
Laboratory.

- 12:00 p.m. 44. "Progress on Impulse Jet Droplet Generator for  
Laminar Spray Combustion Experiments,"  
N. Ashgrizzadeh, S. Yao and W. Sirignano,  
Carnegie-Mellon University.

12:20 p.m. Lunch Break

Session B-2  
Chairperson: Professor M. Sibulkin  
Brown University

#### COAL DUST COMBUSTION

- 2:50 p.m. 45. "Shock Wave Ignition of Pulverized Coal," Erdem  
A. Ural, M. Sichel and C. W. Kauffman, The  
University of Michigan

- 3:10 p.m. 46. "Flame Propagation Experiments with Coal Dust in  
a Large-Scale Laboratory Gallery," S. E. Slezak,  
R. O. Buckius and H. Krier, University of  
Illinois.

3:30 p.m. Coffee Break

- 4:00 p.m. 47. "Coal Combustion Studies with Regenerative  
Pyrolysis," L. Nguyen, V. L. Wolfe, Jr. and  
P. Durbetaki, Georgia Institute of Technology.

- 4:20 p.m. 48. "Modeling the Effects of Volatile Content and  
Heat Loss on the Flame Propagation of Coal Dust-  
Air Mixtures," T. W. Gary Yip, H. Krier, and  
R. O. Buckius, University of Illinois.



Thursday, November 13, 1980

Session A-3

Chairperson: Dr. R. Levine  
National Bureau of Standards

FIRE PHENOMENA

- 9:00 a.m. 14. "Research Needs in Fire Safety," H. W. Carhart, Naval Research Laboratory. (Invited Paper)
- 9:45 a.m. Break
- 9:50 a.m. 15. "Effects of Water on Wood-Charcoal Combustion," P. M. Bhagat, Columbia University
- 10:10 a.m. 16. "Effects of an Insert Fuel Phase Additive on Free Convection Diffusion Flames," M. Sibulkin and C-Y Wang, Brown University.
- 10:30 a.m. Coffee Break
- 11:00 a.m. 17. "A Dimensionless Correlation of the Flame Spread Rate Down Thermally Thick Fuels in the Presence of Free Convection," R. A. Altenkirch, A. R. Rizvi and R. Eichhorn, University of Kentucky.
- 11:20 a.m. 18. "Burning Rate and Flame Temperature Measurements on Vertical Fuel Surfaces," A. K. Kulkarni, Pennsylvania State University, and M. Sibulkin, Brown University.
- 11:40 a.m. 19. "A Boundary Layer Analysis of a Free Burning Horizontal Fuel Surface," C-P Mao and A. C. Fernandez-Pello, University of California.
- 12:00 p.m. 20. "Rapid Measurements of Fire Radiative Properties with a Feedback-Controlled Tungsten Source of Background Radiation," G. H. Markstein, Factory Mutual Research Corporation.
- 12:20 p.m. Lunch Break

Session A-4

Chairperson: Dr. F. Tamanini  
Factory Mutual Research Corporation

FIRE MODELING

- 2:00 p.m. 21. "Scientific Progress in Fire," H. W. Emmons, Harvard University. (Invited Paper)
- 2:45 p.m. Break

- 2:50 p.m. 22. "Turbulent Buoyant Flow and Smoke Layers in a 2-D Rectangular Compartment with Vertical Vents," K. Satoh, J. R. Lloyd and K. T. Yang, University of Notre Dame.
- 3:10 p.m. 23. "Numerical Model of Convection in a Room Fire," R. G. Rehm and H. R. Baum, National Bureau of Standards.
- 3:30 p.m. 24. "Fire Induced Flows Through Room Openings -- Flow Coefficients," K. D. Steckler, Armstrong World Industries, J. G. Quintiere and W. J. Rinkinen, National Bureau of Standards.
- 3:50 p.m. Coffee Break
- 4:20 p.m. 25. "Ventilation and Smoke Layer Thickness Through a Doorway of a Cubic Enclosure with a Central Volumetric Heat Source," K. Satoh, K. T. Yang and J. R. Lloyd, University of Notre Dame.
- 4:40 p.m. 26. "The Effect of Room Openings on Fire Plume Entrainment," J. G. Quintiere and W. J. Rinkinen, National Bureau of Standards.

Session B-3

Chairperson: Dr. E. Oran  
Naval Research Laboratory

IGNITION AND MODELING

- 9:50 a.m. 49. "Ignition of Supercritical Ethylene Oxide Near Heated Vertical Surfaces," L-D Chen and G. M. Faeth, The Pennsylvania State University.
- 10:10 a.m. 50. "Modeling the Effects of Buoyancy on the Thermal Ignition of a Homogeneous Mixture," W. W. Jones, National Bureau of Standards.
- 10:30 a.m. Coffee Break
- 11:00 a.m. 51. "A Numerical Analysis of Flame Flashback in a Premixed System," S. Lee and J. S. Tien, Case Western Reserve University.
- 11:20 a.m. 52. "Solution of Burner-Stabilized Laminar Pre-Mixed Flame Problems by a Boundary Value Method," J. A. Miller, M. D. Smooke and R. J. Kee, Sandia National Laboratories.
- 11:40 a.m. 53. "Numerical Study of the Dependence of Flame Velocity on Transport Coefficients," J. R. Creighton, Lawrence Livermore National Laboratory.



12:00 p.m. 54. "Transport Algorithms for Premixed, Laminar Steady State Flames," T. P. Coffee and J. M. Heimerl, Ballistic Research Laboratory.

12:20 p.m. Lunch Break

Session B-4

Chairperson: Professor H. Krier  
University of Illinois

IGNITION AND MODELING (CONTINUED)

2:50 p.m. 55. "Some Considerations of the Lean Flammability Limit of Some Gaseous Fuels and Their Mixtures," G. A. Karim, S. Boon and I. Wierzb, The University of Calgary.

3:10 p.m. 56. "The Near-Stoichiometric Behavior of Combustible Mixtures: Dissociation of the Products," A. K. Sen, Indiana-Purdue Universities and G. S. S. Ludford, Cornell University.

3:30 p.m. 57. "The Development of an Induction Parameter Model for Simulations of Detonations," E. S. Oran, J. P. Boris, M. J. Picone and T. R. Young, Naval Research Laboratory.

3:50 p.m. Coffee Break

4:20 to 5:30 p.m. - OPEN FORUM

Friday, November 14, 1980

Session A-5

Chairperson: Mr. W. D. Howell  
Federal Aviation Administration Technical Center

FIRE PLUMES

9:50 a.m. 27. "Measurements and Predictions in Buoyant Flames," H-Z You and G. M. Faeth, The Pennsylvania State University.

10:10 a.m. 28. "An Adiabatic Turbulent Diffusive Open Flame Plume Model," T. B. C. Shen, Southeastern Massachusetts University

10:30 a.m. Coffee Break

11:00 a.m. 29. "Flame Height and Virtual Source in Turbulent Fire Plumes," M. A. Delichatsios, Factory Mutual Research Corporation.

11:20 a.m. 30. "Pressure Profiles Generated by Fire Plumes Impacting on Horizontal Ceilings," G. Heskestad, Factory Mutual Research Corporation.

11:40 a.m. 31. "A New Experimental Technique for Measuring the Burning Rate and Product Yield in Fire Plumes," F. Tamanini, Factory Mutual Research Corporation.

12:00 p.m. Lunch Break

Session A-6

Chairperson: Professor B. T. Zinn  
Georgia Institute of Technology

SOOT

1:30 p.m. 32. "Phenomenological Models of Soot Processes in Combustion Systems," I. Glassman, Princeton University. (Invited Paper)

2:15 p.m. Break

2:20 p.m. 33. "The Effect of Molecular Structure on the Tendency to Soot," H. F. Calcote and D. M. Manos, AeroChem Research Laboratories, Inc.

2:40 p.m. 34. "Mobility Measurements of Atomic Ions and Possible Soot Precursors in Flames Using Opto-Galvanic Spectroscopy," W. G. Mallard and K. C. Smyth, National Bureau of Standards.

3:00 p.m. Coffee Break

3:30 p.m. 35. "Effects of Fuel Composition and Structure on Soot Formation in Gas Turbine Combustion," D. W. Naegeli and C. A. Moses, Southwest Research Institute.

3:50 p.m. 36. "Soot Formation in Jet-Stirred Combustors," R. M. Kowalik and L. A. Ruth, Exxon Research and Engineering Company.

4:10 p.m. 37. "A Study of Soot Suppression by Water Addition to Fuel," E. T. McHale and E. G. Skolnik, Atlantic Research Corporation.

4:30 p.m. 38. "A Theoretical Investigation of Smoldering and Smoke Formation by Porous Solid Fuels," K. Kailasanath and B. T. Zinn, Georgia Institute of Technology.

4:50 p.m. Closing Remarks



Session B-5

Chairperson: Dr. D. J. Bogan  
Naval Research Laboratory

CHEMICAL KINETICS

- 9:00 a.m. 58. "Kinetics of Polyatomic Free Radicals Important in Combustion Processes," D. Gutman, Illinois Institute of Technology.
- 9:45 a.m. Break
- 9:50 a.m. 59. "High Temperature Photochemistry (HTP), a new Technique for Rate Coefficient Measurements Over Wide Temperature Ranges: Measurements on the  $O + CH_4$  Reaction from 420-1670 K," W. Felder and A. Fontijn, AeroChem Research Laboratories.
- 10:10 a.m. 60. "Applications of Sensitivity Analysis to Combustion and Kinetics," H. Rabitz, Princeton University.
- 10:30 a.m. Coffee Break
- 11:00 a.m. 61. "A Multi-Step Overall Kinetic Mechanism for the Oxidation of Hydrocarbons," D. J. Hautman, F. L. Dryer, K. P. Schug and I. Glassman, Princeton University.
- 11:20 a.m. 62. "Methodology for Construction of Large Reaction Mechanisms: Low Temperature n-Butane Oxidation," M. Maday, R. S. Sheinson, F. Williams, W. Shaub and D. Indritz, Naval Research Laboratory.
- 11:40 a.m. 63. "Thermogravimetric Fingerprints of Complex Solid Phase Pyrolysis Mechanisms and Kinetics," M. J. Antal, Jr., Princeton University.
- 12:00 p.m. 64. "Russell Termination Reactions of Alkyl Peroxy Radicals, Analysis of Experiment and Theory," D. J. Bogan, Naval Research Laboratory
- 12:20 p.m. Lunch Break

Session B-6

Chairperson: Dr. H. G. Semerjian  
National Bureau of Standards

- 2:20 p.m. 65. "CARS Concentration Sensitivity with and without Nonresonant Background Suppression," A. C. Eckbreth and R. J. Hall, United Technologies Research Center.
- 2:40 p.m. 66. "Raman Studies of Premixed Methane-Nitrous Oxide Flames," R. A. Beyer, J. A. Vanderhoff, A. J. Kotlar, Ballistic Research Laboratory.
- 3:00 p.m. Coffee Break
- 3:30 p.m. 67. "Measurement of OH and NH Concentration Profiles in Stoichiometric  $CH_4/N_2O$  Flames by Laser Excited Fluorescence," W. R. Anderson, L. J. Decker and A. J. Kotlar, Ballistic Research Laboratory.
- 3:50 p.m. 68. "Laser Fluorescence Measurements of the OH Concentration in Boundary Layer Combustion," R. J. Cattolica, Sandia National Laboratories and R. W. Schefer, Lawrence Berkeley Laboratory.
- 4:10 p.m. 69. "Vibrational Energy Transfer in  $AE\ OH$  in Flames," D. R. Crosley and G. P. Smith, SRI International.
- 4:30 p.m. 70. "Optical Tomography for Flow Field and Combustion Diagnostics," R. J. Santoro and H. G. Semerjian, National Bureau of Standards, P. J. Emmerman and R. Goulard, George Washington University.