

ANNUAL REPORT FOR THE CENTER FOR ENERGY AND COMBUSTION RESEARCH

University of California, San Diego

July 1, 1986 - June 30, 1987

CENTER FOR ENERGY AND COMBUSTION RESEARCH

S. S. Penner, Director
K. Seshadri, Assoc. Dir.
for Combustion Research
E. Goldberg, Assoc. Dir.
for Environmental Studies
J. Richardson, Admin. Asst.

ADMINISTRATIVE DEVELOPMENTS

Active faculty participants during the period 1986-1987 included Associate Directors E. D. Goldberg (SIO) and K. Seshadri (AMES), as well as A. L. Berlad, A. S. Gordon, P. A. Libby, and M. T. Simnad (all in AMES).

Some minor progress was made during 1986-87 toward the development of a significant program dealing with environmental studies in the CECR but much remains to be done. On the other hand, combustion research and related seminars and lectures have assumed a proper dominant role for CECR scheduled activities.

FUNDING AND RESEARCH

A major program pursued during 1986 and 1987 included completion of a nation-wide, DOE-sponsored study on advanced coal-gasification technologies (S. S. Penner et al). The output of this work has been printed as a 300-page book by Pergamon Press (September 1987). A small grant from the Universitywide Energy Research Group on mass burning of municipal wastes led to five published articles and supplementary funding from the Energy Research Foundation.

A major NASA-sponsored research effort on combustion under micro-gravity conditions is continuing under the direction of A. L. Berlad. S. S. Penner has been appointed to a reconstituted NASA advisory committee dealing with this topic. As a part of this effort, P. A. Libby conducted under NASA sponsorship an experimental and theoretical study on the influence of gravity on the rate of propagation and structure of premixed turbulent flames. Fundamental combustion research on diffusion flames, sponsored by NSF and ARO, is continuing under the direction of K. Seshadri; A. S. Gordon has been an active participant in these investigations. M. T. Simnad is involved in a variety of studies in materials science (e.g., materials for coal gasification and nuclear reactors), while continuing studies on the influence of atmospheric pollution on materials and structures (in collaboration with F. Seible). P. A. Libby and K. Seshadri, in collaboration with F. A. Williams, have initiated under DOE sponsorship an experimental and theoretical investigation of the behavior of fuel droplets in a well defined flow involving rapid variations in velocity, composition and temperature in order to assess the validity of current theoretical descriptions of such behavior. P. A.

Libby is continuing theoretical studies on premixed turbulent combustion under DOE sponsorship, with particular emphasis on the influence of stretch on premixed turbulent flames.

A summary of funding and expenditures for the period July 1, 1986 to June 30, 1987, is given in Table 1.

Table 1. RESEARCH FUNDING FOR THE CENTER FOR ENERGY AND COMBUSTION RESEARCH
July 1, 1986 to June 30, 1987

Principal Investigator	Contract/Grant No.	Title	Period	Budget Allocation	Expenditure
Berlad, A. L.	NASA L-NAS 3-24639	Scientific Support for an Orbiter Middeck Experiment on Particle Cloud Combustion	09-01-85/ 08-31-88	393,000	141,320
Libby, P. A.	NASA NAG 3-654	Effect of Gravity on Premixed Turbulence Flames	09-05-85/ 10-31-87	88,318	30,139
Libby, P. A.	DoE DE-FG03-86-ER13527	Premixed Turbulent Combustion	06-01-86/ 11-30-87	78,270	22,987
Libby, P. A./ Seshadri, K.	DoE DE-FG03-87-ER13685	Experimental and Theoretical Study of Fuel Droplets Subject to a Straining Flow	03-15-87/ 03-14-88	93,000	14,784
Penner, S. S.	Energy Research Foundation	For Support of Research, Instruction, and Other Related Activities	01-13-84/ 06-30-87	66,363	49,808
Penner, S. S.	DoE DE-AC01-85-ER30076	Assessment of Surface Coal-Gasification Research Needs	09-30-85 08-15-87	190,225	137,065
Penner, S.S.	Universitywide Energy Research Group	Mass Burning of Municipal Wastes	07-01-86/ 06-30-87	11,500	11,500
Sebald, A. V.	Universitywide Energy Research Group	A Conditional Demand Model for Enhanced Energy on UC Campuses	07-01-86/	3,538	3,538
Seshadri, K.	NSF CPE 83-12042	Structure and Extinction of Laminar Flames	10-15-84/ 03-31-87	159,177	102,552
Seshadri, K.	ARO DAAL-03-86-K-0001	Mechanisms of Combustion of Hydrocarbon/Alcohol Fuel Blends	10-15-85/ 10-14-88	180,000	77,698
Seshadri, K.	Academic Senate Grant RL 114-G	Structure of Laminar Flames	07-01-86 06-30-87	3,996	3,720
Seshadri, K.	NSF INT 86-09939	U.S.-Federal Republic of Germany Cooperative Research: The Influence of Stretch on the Structure and Propagation velocity of Counterflow, Premixed Flames	01-15-87 01-14-89	10,243	-0-
TOTALS				\$1,277,630	\$595,111

PARTICIPANTS

The number of graduate and post-doctoral students directly contributing to the unit and on the unit payroll was 6; other students and post-doctoral participants numbered 4.

There were 7 faculty participants.

Faculty from other campuses working on combustion research have been regular visitors to UCSD and have participated in campus programs through formal lectures and informal discussions.

The number of FTE administrative personnel employed is 1.

PUBLICATIONS

1. "Mass Burning of Municipal Wastes" by S. S. Penner, D. F. Wiesenbahn and C. P. Li, Annual Reviews of Energy 12, 415-444 (1987).
2. "A Simplified Model for Dioxin Formation in Municipal Waste Incinerators" by D. F. Wiesenbahn, C. P. Li and S. S. Penner, Energy (in press 1988).
3. Coal Gasification: Direct Applications and Syntheses of Chemicals and Fuels, 300 pp., by S. S. Penner, S. B. Alpert, J. M. Beér, M. Denn, W. Haag, R. Magee, E. Reichl, E. S. Rubin, P. R. Solomon, I. Wender, and K. Woodcock, Pergamon Press, NY (September 1987) and Energy 12, 623-903 (1987).
4. "Production of Toxic Equivalents to 2,3,7,8-TCDD in Municipal Waste Incinerators (MWIs)" by C.-P. Li, D. F. Wiesenbahn and S. S. Penner, Energy (in press 1988).
5. "A Model for Dioxin and Furan Production in Municipal Waste Incinerators" by S. S. Penner, C.-P. Li, and D. F. Wiesenbahn in 11th International Colloquium on Gasdynamics of Explosions and Reactive Systems, AIAA (in press 1988).
6. "Autoignition of Fuel-Oxidizer Mixtures in Microgravity" by A. L. Berlad, Progress in Astronautics and Aeronautics 108, 201 (1986).
7. "Particle Cloud Kinetics in Microgravity" by A. L. Berlad, N. D. Joshi, H. Ross, and R. Klimek, AIAA paper number 87-0577 (Jan. 1987).
8. "Extinction of Diffusion Flames Burning Diluted Methane and Diluted Propane in Diluted Air" by I. Puri and K. Seshadri, Combust. and Flame 65, 137-150 (1986).
9. "A Comparison Between Numerical Calculations and Experimental Measurements of the Structure of a Counterflow Diffusion Flame Burning Diluted Methane in Diluted Air" by M. D. Smooke, I. K. Puri and K. Seshadri in Twenty-First (International) Symposium on Combustion, The Combustion Institute, Pittsburgh, Pennsylvania, (1988).
10. "The Structure of Coflowing, Laminar, C₂ Hydrocarbon - Air Diffusion Flames" by A. Hamins, A. S. Gordon, K. Seshadri, and K. Saito, in Twenty-First (International) Symposium on Combustion, The Combustion Institute, Pittsburgh, Pennsylvania (1988).
11. "The Structure of Diffusion Flames Burning Pure, Binary and Ternary Solutions of Methanol, Heptane and Toluene" by A. Hamins and K. Seshadri, Combust. and Flame, (in press 1987).

12. "The Influence of Hydrogen Addition on Methane-Air Flames" by I. K. Puri, C. Treviño and K. Seshadri, *Combust. and Flame*, submitted (1987).
13. "Mechanisms of Extinction of Counterflow Premixed Flames Burning Lean Mixtures of Methane-Air and Propane-Air" by I. Puri and K. Seshadri, *Combust. Sci. Tech.*, (in press 1987).
14. "The Asymptotic Structure of Counterflow, Methane-Air Diffusion Flames with Four-Step Kinetics" by K. Seshadri and N. Peters, submitted (1987).
15. "A Comparison between Numerical Calculations and Experimental Measurements of the Structure of Counterflow Methane-Air Diffusion Flame" by I. Puri, K. Seshadri, M. D. Smooke, and D. E. Keyes, *Combust. Sci. Tech.*, submitted (1987).
16. "Gravitational Effects on the Structure and Propagation of Premixed Flames" by A. Hamins, M. Heitor and P. A. Libby, 37th Congress of the International Astronautical Federation, Innsbruck, Austria, October 1986, Pergamon Press (1987); also *Acta Astronaut.*, submitted.
17. "The Burning of Graphite Spheres with Gas-Phase Equilibrium" by D.-G. Xie and P. A. Libby, *Combust. and Flame* 67, 37-54 (1987).
18. "Premixed Combustion" by P. A. Libby, S. Sivasegaram and J. H. Whitelaw, *Prog. Energy Combust. Sci.* 12, 393-405 (1986).
19. "Turbulent Reactive Boundary Layer with Non Isenthalpic Conditions" by K. N. C. Bray, M. Champion and P. A. Libby, *Combust. Sci. Technol.*, submitted (1987).
20. "Premixed Laminar Flames with General Rates of Strain" by P. A. Libby and F. A. Williams, *Combust. Sci. Technol.*, submitted (1987).
21. "Acetone Impurity in Acetylene from Tanks" by A. Hamins, A. S. Gordon, K. Saito, and K. Seshadri, *Combust. Sci. and Tech.* 45, 309-310 (1986).
22. "A Study of C₂ Hydrocarbon Diffusion Flames" by A. S. Gordon, Twenty-First Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA (1988).
23. "Materials and Fuels Selection and Development Program for the STAR-C Space Nuclear Thermionic Power Reactor" by M. T. Simnad, section of GA-Technologies Report to DOE/DOD/NASA (November 1986).
24. "Materials and Fuels for Nuclear Power Reactors" by M. T. Simnad, invited contribution to Encyclopedia of Applied Physical Science and Technology, Academic Press (in press 1987).

25. "Review of Fuel Element Developments for Water-Cooled Nuclear Power Reactors" by M. T. Simnad, invited manuscript for the International Atomic Energy Agency, to be published as a Special Technical Publication, IAEA, Vienna (1987).

ADVISORY COMMITTEE

The ORU Advisory Committee was not reconstituted or convened during 1986-87. There were, however, continued extensive formal and informal faculty reviews for the purpose of defining future CECR program goals and objectives.

INSTRUCTIONAL PROGRAMS

Undergraduate and graduate instruction were offered, as in prior years, on energy- and combustion-related topics within the Department of AMES and the Program on Science, Technology and Public Affairs.

The ORU sponsors a general series of seminars and public lectures in its areas of activities. A partial listing of these seminars is given in Table 2.

Table 2. SEMINARS PRESENTED AT THE CENTER FOR ENERGY AND COMBUSTION RESEARCH (JULY 1, 1986 - JUNE 30, 1987)

Date	Speaker	Topic
October 9	A. Fontijn, Rensselaer Polytechnic Institute	High-Temperature Reactor Studies of Homogeneous Elementary Reactions
January 29	D. F. Wiesenbahn and C. P. Li, UCSD	Municipal Waste Incinerator Modeling, Designs and Toxic-Pollutant Production
February 20	A. R. Karagozian, UCLA	Vortex Modeling of Reacting Flow Processes in Hazardous Waste and Other Combustion Systems
March 6	C. Treviño, University Nacional Autonoma de Mexico	Asymptotic Analyses of the Structure and Extinction of Methane-Air Diffusion Flames
March 12	C. F. McDonald, GA Technologies, Inc.	Advanced, Very High Temperature Gas-Cooled Reactor Concepts for the 21st Century
March 21	K. C. Smyth, National Bureau of Standards	Chemical Growth in Hydrocarbon Diffusion Flames
April 3	K. Seshadri, UCSD	Experimental and Theoretical Combustion Studies with Realistic Kinetics
April 10	A. L. Berlad, UCSD	The NASA Program on Low-Gravity Combustion
April 17	A. C. Fernandes-Pello, UCB	Fire Research
April 22	B. Butler, SAIC	Recent Developments in High Power Density Sodium/Sulfur Batteries
April 27	O. I. Smith, UCLA	Experimental and Numerical Investigations of Flames of Interest in Propellant Applications
May 1	W. Heiser and D.T Pratt, Aerojet-General	The Aerospaceplane and Propulsion by Supersonic Combustion or Oblique Detonation

able 2 (Continued)

Date	Speaker	Topic
May 8	R. Cattolica, Sandia/Livermore	Recent Developments in Combustion Diagnostics
May 15	S. Warnatz, Heidelberg	Kinetic Modeling in Combustion Systems
May 21	K. Kedward, Alcoa Defense Systems	The Impact of Materials Research on Composite Structures Development
May 22	R. Sawyer, UCB	Engine Combustion
May 29	D. Smooke, Yale	Numerical Analysis of Combustion Systems
June 2	B. Butler, SAIC	Advances in Solar Energy Materials
June 5	J. Tishkoff, AFOSR	AFOSR Program in Supersonic Com- bustion
une 12	W. Kollmann, UCD	Combustion in Turbulent Flows

PUBLIC RELATIONS ACTIVITIES

Faculty and staff members associated with the UCSD Center of Energy and Combustion Research continue to be heavily involved in energy policy and analysis activities and studies at local, state, national and international levels. The editorial offices for Energy, The International Journal (published by Pergamon Press in London, England, since 1975) remain housed at the UCSD Center for Energy and Combustion Research.

SPACE USED

Drs. Penner, Seshadri, Berlad, and Gordon, the administrative assistant, and the graduate students occupied Rooms 6246, 6250, 6254, 6257 A, B, C, & D, and 6258 in Urey Hall. Other participants used space allocated to them by their respective departments.