COMBUSTION THEORY AND RELATED QUESTIONS
FINAL REPORT
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Combustion Theory and Related Questions

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Modern asymptotic methods have been applied to a wide range of problems in combustion science and mechanics. Details are contained in the 22 Technical Reports and 5 Ph.D. theses listed. A list of participating scientists is also given.
Objectives and Results

Asymptotic methods were applied to a variety of combustion and related problems, including:

(i) stability of tube-burner diffusion flames
(ii) flow-field generated by diffusion flame combustion
(iii) calculation of the unsteady motion of detonation fronts
(iv) shock induced explosion of solid explosives
(v) stability of diffusion flames near extinction
(vi) effects of stagnation point flow on premixed flames
(vii) the stability of plane detonation waves
(viii) flammability limits described by models for complex chemistry
(ix) shear bands in materials for which the plastic strain rate is sensitive to the thermomechanical state
(x) structure of detonation waves in granular propellants
Publications

22 Technical Reports were written, as follows:


183 'An introduction to combustion theory' by J.Buckmaster, chapter in Mathematics in Combustion, a volume in the SIAM series 'Frontiers in Applied Mathematics'.

184 'The contribution of asymptotics to combustion' by J.Buckmaster, Physica D,20,9(1986)


190 'Numerical aberrations in a Stefan problem from detonation theory' by G.S.S.Ludford and A.A.Oyediran, Transactions of the 3rd Army Conference on Applied Mathematics and Computing (at Atlanta, Georgia).


193 'Displacement effect of a flame in a stagnation-point flow' by E.Eteng, G.S.S.Ludford, and M.Matalon, to be published in Physics of Fluids.


198 'Stability of a detonation wave' by F.S.Hall and G.S.S.Ludford, to appear in Physica D.


201 'Structure of two phase steady detonation and composition waves' by J.Powers, D.Stewart, and H.Krier, submitted for publication.

202 'Shear bands and localization theory in nonlinear solids' by D.Stewart, submitted for publication.
Ph.D Theses

5 were completed, as follows:

R.Y. Tam 'Complex Kinetics in Combustion Modeling', August 1986
Y.S. Choi 'Chambered diffusion flame with general Lewis number', August 1986
F. Hall 'Stability of a detonation wave', January 1987
A. Oyediran 'Unsteady detonations', June 1985
E. Eteng 'Density-stratified stagnation-point flow' June 1986

In addition, M. Williams completed a Master's thesis based on Technical Report 182.
Account of research of Charles Roten, Visiting Assistant Professor, July 1986 - August 1987

1. preprint:

"Modelling and Analysis of H₂-O₂ combustion between 1100 and 1600 degrees", C.D. Roten and P.C. Fife.

M.S.I. Technical Report - same title presented at


Abstract:

A detailed nonnumerical analysis of hydrogen-oxygen combustion at 1 atmosphere between 1100° and 1600° is presented. MACSYMA is used to implement an algorithm which constructs candidates for the allocation vector by a comparison of the reaction rate functions which accounts for competition, autocatalysis, and partial equilibrium of reactions. A method for examining how these allocations change with temperature is also presented. A "plateau" temperature toward which the reaction temperature tends is found for the case where the initial mixture is hydrogen-rich. In the hydrogen-lean case successive bifurcations of strongly and weakly recombinant chemistries leads to a set of upper and lower bounds for the plateau temperature. The global chemical reactions which dominate the stoichiometry are found for both cases, and the heat release in the reaction zone is determined as a function of the relative participation of the different global reactions.
2. preprint:


Abstract:

The problem of finding limit points in bifurcation diagrams of nonlinear boundary value O.D.E.'s is examined. Bifurcation curves for singular and nonsingular boundary value O.D.E.'s are constructed by Poincare-Linstedt expansions, and numerically. The local expansions are found to agree with the numerical results only for the nonsingular problems and for points on the singular problems' bifurcation diagrams between the initial bifurcation point and the O.D.E.'s singular solution. The numerical results at the singular points on the bifurcation curves are shown to be qualitatively correct. An asymptotic method for location of the singular solutions is developed and justified. The local expansions are shown to predict their own failure in the singular problems.
Participating Scientists

Y.S. Choi, R.Y. Tam, F. Hall, E. Eteng were supported for various periods as Research Assistants.

Professor J.D. Buckmaster of the University of Illinois, Urbana, was a Visiting Professor for various periods. Professor D.S. Stewart of the University of Illinois, Urbana, was a visiting Assistant Professor. Professor C. Roten of Mississippi State University was a Visiting Assistant Professor. Dr. C. Laine of the Ecole Centrale de Lyon was a Visiting Scientist.
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