

**An investigation into the origin, measurement and
application of chemiluminescent light emissions
from premixed flames**

by

Ludwig Christian Haber, B. S.

Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Master of Science

in

Mechanical Engineering

APPROVED:

Dr. Uri Vandsburger

Dr. Clint L. Dancey

Dr. William R. Saunders

April 2000

Blacksburg, Virginia

Keywords: Chemiluminescence, Combustion, Modelling

An investigation into the origin, measurement and application of chemiluminescent light emissions from premixed flames

Ludwig Christian Haber, M.S.

Virginia Polytechnic Institute and State University, 2000

Advisor: Dr. Uri Vandsburger

ABSTRACT

The chemiluminescent species CH^* and OH^* are studied in premixed methane combustion to investigate the possible application of their light emissions in gas turbine combustion monitoring systems. The interpretation of integrated and local chemiluminescence measurements are shown to give important qualitative insights into the burning process. The formation path of OH^* chemiluminescence is clarified and an accurate chemical kinetic model predicting OH^* chemiluminescence emission is developed using GRIMECH 3.0 as a starting point for methane oxidation. CH^* chemiluminescence is also modeled but difficulties in obtaining quenching data make the modeling efforts somewhat less successful than that for OH^* chemiluminescence. Two combustion models are developed. The first is a semi-empirical model for a Bunsen type flame. The second is a 1-D model for a ceramic honeycomb flat-flame burner using the full chemical kinetics description of the conversion from fuel to products along with a detailed energy equation, accounting for the radiation energy exchange between hot gases and the honeycomb burner ceramic. The results of the modeling calculations show that OH^* is superior to CH^* chemiluminescence in terms of indicating heat-release rate. The formation of the ratio between CH^* and OH^* chemiluminescence is shown to be an accurate indicator of equivalence ratio.

Acknowledgments

I would like to thank Dr. Uri Vandsburger for his patience, technical expertise and encouragement in my research. I greatly appreciate the latitude I was given in pursuing the research contained in this thesis. The lessons I learned in the approach to research will serve me well in the rest of my research career.

I would also like to thank Dr. William Saunders for countless discussions which helped motivate the detail of the research as well as keep in focus the final goal of the research that is the application of the knowledge to real measurement situations.

Furthermore, I want to thank Dr. Clint Dancey not only for his help on my committee but also for the excellent teaching in two undergraduate classes I was fortunate to be in.

Finally, I want to thank especially my family as well as all my friends for their support of this undertaking. With your help and support I hopefully will be able to complete the next steps in my life with equal success. Thank you.

LUDWIG CHRISTIAN HABER

Virginia Polytechnic Institute and State University

April 2000

To my family