ABSTRACT BOOKLET

The Eighth Asia-Pacific International Symposium on Combustion and Energy Utilization (8th APISCEU)

October 10-12, 2006

Venue
Zapolarye Health & Spa Center, Sochi, Russian Federation

Sochi - 2006

Jointly Organized by

Institute of Engineering Thermo-Physics, Chinese Academy of Sciences, China

Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Izhevsk, Russian Federation

Sochi Research Center, Russian Academy of Science, Sochi, Russian Federation

Sponsored by:

The Union of Scientific and Engineering Societies of the Udmurtia Republic, Izhevsk, Udmurtia Republic, Russian Federation

Research & Production Association of the Special Materials, Saint Petersburg, Russian Federation Web-site: http://www.npo-sm.ru

ISBN 5-89238-085-8

First Edition 2006

Printed in Sochi, Russian Federation

Editors:
Alexey M. Lipanov
Alexander N. Lukin

Published by the Sochi Research Center (SRC)
of the Russian Academy of Science

Document designed by Dr. Alexander N. Lukin at SRC by Adobe Acrobat 6.0.0.0

Preface

The Eighth Asia-Pacific International Symposium on Combustion and Energy Utilization (8^{th} APISCEU) is the eighth of a series of symposia organized to provide a forum for researchers in the areas of combustion and energy utilization for exchanging scientific ideas and discussing the common problems amongst Asia-Pacific countries. This series of symposia was first held in Beijing in 1990 with the Chinese Academy of Sciences and the Hong Kong Polytechnic University as joint organizers. The second symposium was held in Beijing in 1993. The third symposium was held in Hong Kong in 1995. The 4th APISCEU was held in Bangkok in 1997, the 5th APISCEU was held in Shanghai in 1999, the 6th APISCEU was held in Kuala Lumpur in 2002 and the 7th APISCEU was held again in Hong Kong SAR, in 2004 at the Hong Kong Polytechnic University.

Due to the kind invitation, provided by the International Organizing Committee of the Symposium, the next, eighth Symposium is organized in Sochi, the famous Russian recreation resort on the Black Sea shore.

This is a three-and-one-half-day symposium with 60 technical papers accepted for presentation and with two invited keynote papers. The invited talks cover two broad topics; they are some problems in fundamental combustion and combustion diagnostics. Invited speakers are specialists in their own areas and they are from China and Russia. There are five technical sessions and they cover areas such as combustion fundamentals, alternative fuels and renewable energy, computational combustion, combustion diagnostics and emission control of the solid waste combustion. These topics are of relevance to situations in Russia and in the Asia-Pacific region. The technical sessions provide a forum where the latest research is presented, discussed and where new research is stimulated. Equally significant, the symposium provides a meeting place for researchers to interact, to exchange new ideas, to renew old friendships, and to forge new ones in the spirit of scientific collaboration and camaraderie.

The Local Organizing Committee would like to take this opportunity to welcome all delegates to Sochi. We hope that you will find the technical sessions stimulating and that you will leave each session with new thoughts and ideas. We, however, hope that you will not just immerse in the technical sessions, but also take time out to see beautiful Sochi and thoroughly enjoy your stay in this diversified city. No matter what time of the year you come here, the picture is the same - sunshine and greenery all over. There are few cities in the world so rich in greenery as Sochi. Three-quarters of its territory are under parks and gardens with 85 per cent of evergreens. Sochi has something for everyone.

The Local Organizing Committee also would like to take this opportunity to thank the co-organizers, the International Organizing Committee, the Technical Organizing Committee for a job well done in its selection of the technical papers, and the Sochi Tourist Company - Joint-Stock Company "SG Tours".

The Local Organizing Committee would like to thank the sponsors of this symposium for their support; these include the Union of Scientific and Engineering Societies of the Udmurtia Republic (Izhevsk, Udmurtia Republic, Russia) and Research & Production Association of the Special Materials (Saint Petersburg, Russia).

Finally, we wish to thank the members of the Symposium Scientific Committee, the authors of all the Symposium papers and, last but not least, you, the participants in this Symposium, for its success and its influence on the continued success and growth of all future APISCEU meetings.

Alexey M. Lipanov

Co-Chairman

Local Organizing Committee 8thAPISCEU

Sochi, October 2006

International Organizing Committee of APISCEU (2006 年)

General Secretary of APISCEU:

LIU, Shi	Institute of Engineering Thermo-Physics, CAS, China

Vice General Secretary of APISCEU:

LIU, Xin	Institute of Engineering Thermo-Physics, CAS, China

Honorary Chairman:

HUANG, Zhaoxiang	Institute of Engineering Thermo-Physics, CAS, China

Chairman:

ZHANG, Xiaoqian	Institute of Engineering Thermo-Physics, CAS, China

Secretary:

LIU, Xin	Institute of Engineering Thermo-Physics, CAS, China

Members:

BAEK, Seung Wook	Korea Advanced Institute of Sciences, Korea
BASTOS-NETTO, D.	INPE – National Institute for Space Research, Brazil
CAVALIERE, Antonio	University Naples, Italy
CHAMPION, M.	CNRS, FRANCE
CHAO, Y.C.	National Cheng Kung University, Taiwan
CHEN, Dezhen	Tongji University, China
CHEUNG, Chun Shun	The Hong Kong Polytechnic University, Hong Kong SAR, China
CHUNG, Suk-Ho	Seoul National University, Korea
CUKIERMAN, Ana Lea	Universidad de Buenos Aires, Argentina
GÖKALP, Iskender	CNRS, France
HAWLEY, J.G.	University of Bath, United Kingdom
HIRANO, Toshisuke	Chiba Institute of Science, Japan
ISHIZUK, Satoru	Hiroshima University, Japan

JAROSINSKI, J.	Institute of Aeronautics, Poland
KADOTA, Toshikaz	Osaka Prefecture University, Japan
KOBAYASHI, Hideaki	Tohoku University, Japan
LAKSHMISHA, K.N.	Indian Institute of Science, India
LAW, C.K.	Princeton University, USA
LEE, John H.S.	McGill University, Canada
LI, Benqiang	Washington State University, USA
LIPANOV, Alexey M.	Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Russia
LIU, Shi	Institute of Engineering Thermo-Physics, CAS, China
MA, Hsiao-Kang	National Taiwan University, Taiwan
MASRI, Assaad Rachid	University of Sydney, Australia
NIIOKA, T.	Tohoku University, Japan
NIKAZAR, M.	Amirkabir University of Technology, Iran
SMITH, David B.	University of Leeds, England
TAKEI, M.	Nihon University, Japan
WALL, Terry F.	University of Newcastle, Australia
WEBER, Roman	TU Clausthat, Germany
WU, Daohong	Beijing Shenwu Thermal Energy Technology Co., LTD, China
XIA, Dehong	University of Science and Technology Beijing, China
YANG, J.T.	National Tsinghua Univeristy, Taiwan
YAO, Qiang	Tsinghua University, China
ZHANG, Dong-Ke	Curtin University of Technology, Australia
ZHANG Xiaoqian	Institute of Engineering Thermophysics, CAS, China
ZHOU, Lixing	Tsinghua University, China

Technical Committee

Co-Chairman:

Acad. LIPANOV, A.M.	Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Izhevsk, Russia

Co-Chairman:

Prof. AMIRKHANOV, M.M.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia

Secretary:

Dr. VAPIROV, Yu.M.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia

Secretary:

Dr. LUKIN, A.N.	Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Izhevsk, Russia

Members:

Dr. RYBAK, E.A.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia
Dr. KIZILOVA, O.V.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia
Prof. KIDIN, N.I.	Institute of Problems in Mechanics, Russian Academy of Sciences, Moscow, Russia
Prof. SO, R.M.C.	The Hong Kong Polytechnic University, Hong Kong SAR
Prof. LEUNG, C.W.	The Hong Kong Polytechnic University, Hong Kong SAR
Prof. ZHANG, D.K	Curtin University of Technology, Australia
Prof. LEE, J.H.S.	McGill University, Canada
Prof. CEN, K.F.	Zhejiang University, China
Prof. HUANG, Z.	Shanghai Jiaotong University, China
Prof. ZHANG, X.Q.	Chinese Academy of Sciences, China
Prof. CHAMPION, M.	Laboratoire de Combustion et de Detonique, France
Prof. CHOW, W.K.	The Hong Kong Polytechnic University, Hong Kong SAR
Prof. KADOTA, T.	Osaka Prefecture University, Japan
Prof. WHITELAW, J.H.	Imperial College/London University, UK
Prof. LAW, C.K.	President of the Combustion Institute, Princeton University, USA
Prof. VISKANTA, R	Purdue University, USA

Local Organizing Committee

Co-Chairman:

Acad. LIPANOV, A.M.	Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Izhevsk, Russia

Co-Chairman:

Prof. AMIRKHANOV, M.M.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia

Secretary:

Dr. VAPIROV, Yu.M.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia

Secretary:

Dr. LUKIN, A.N.	Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Izhevsk, Russia

Secretary:

Dr. KIZILOVA, O.V.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia

Members:

Dr. RYBAK, E.A.	Sochi Research Center of the Russian Academy of Science, Sochi, Russia
Ms. SAIDAKOVSKAYA, L.V.	Touristic Company "SG Tours", Sochi, Russia

Opening Ceremony

October 10, 2006

Venue: Big Hall of the Zapolarye Health & Spa Center

09:00 Introduction
Prof. A.M. LIPANOV
Director, Institute of Applied Mechanics,
Ural Branch of the Russian Academy of Sciences
Co-Chairman, Local Organizing Committee, 8th APISCEU, Russia

09:03 Welcoming Speech
Prof. ZAHNG, XIAOQIAN
Institute of Engineering Thermo-Physics,
Chinese Academy of Sciences, China
Chairman, International Organizing Committee of the APISCEU

09:10 Welcoming Speech
Prof. M.M. AMIRKHANOV
Director, Sochi Research Center,
Russian Academy of Science
Co-Chairman, Local Organizing Committee, 8th APISCEU, Russia

09:17 Opening Speech by the Guest of Honor
SOCHI Administration, Russia

09:21 Welcoming Speech
Prof. HUANG ZHAOXIANG
Institute of Engineering Thermo-Physics
Chinese Academy of Sciences, China
Honorary Chairman of the International Organizing
Committee of the APISCEU

09:25 Ribbon Cutting Ceremony

Technical Program

The Eighth Asia-Pacific International Symposium on Combustion and Energy Utilization

10-12 October 2006, Sochi, Russian Fedration

October 09, 2006 (Monday)

14:00 – 18:30 Registration, Hall of the Zapolarye Health & Spa Center
18:30 – 23:00 Welcome Dinner, Restaurant of the Zapolarye Health & Spa Center

October 10, 2006 (Tuesday)

08:00 – 09:00 Registration, Hall of the Zapolarye Health & Spa Center
09:00 – 09:25 Opening Ceremony, Big Hall of the Zapolarye Health & Spa Center

09:30 – 10:40 Keynote Session, Big Hall of the Zapolarye Health & Spa Center

11:00 – 12:20 Technical Sessions, Big Hall of the Zapolarye Health & Spa Center

12:20 – 14:00 Lunch, Restaurant of the Zapolarye Health & Spa Center
14:00 – 18:00 Cultural Program: Sightseeing Tour of Sochi and Visit to the Joseph Stalin's Dacha (Summer Residence)

October 11, 2006 (Wednesday)

08:30 – 09:30 Registration, Hall of the Zapolarye Health & Spa Center
09:00 – 12:20 Technical Sessions, Big Hall of the Zapolarye Health & Spa Center
12:20 – 14:00 Lunch, Restaurant of the Zapolarye Health & Spa Center
14:00 – 18:00 Technical Sessions, Big Hall of the Zapolarye Health & Spa Center

October 12, 2006 (Thursday)

09:00 – 12:40 Technical Sessions, Big Hall of the Zapolarye Health & Spa Center
12:40 – 14:00 Lunch, Restaurant of the Zapolarye Health & Spa Center
14:00 – 17:00 Technical Sessions, Big Hall of the Zapolarye Health & Spa Center
17:00 – 17:40 Poster Sessions, Big Hall of the Zapolarye Health & Spa Center
19:00 – 23:00 Symposium Banquet (Restaurant of the Zapolarye Health & Spa Center)

Keynote Session - Invited Keynote lectures

Date: October 10, 2006 (Tuesday)

Venue: Big Hall of the Zapolarye Health & Spa Center

Time: 09:30 – 10:40

Session Chair: Prof. Toshisuke Hirano

09:30 – 10:05

KN-101 Study on Flow and Combustion Visualization
Prof. Shi Liu
Institute of Engineering Thermo-Physics, CAS, China

10:05 – 10:40

KN-102 About Results of the Numerical Solution of the Hydromechanics Equations
Prof. Alexey M. Lipanov
Institute of Applied Mechanics, UB of the RAS, Russian Federation

10:40 – 11:00 Tea Break

Technical Sessions

October 10, 2006

AM 09:00 – 09:25
Big Hall of the Zapolarye Health & Spa Center
Opening Ceremony

AM 09:30 – 10:40 (Tea break: 10:40 – 11:00)
Big Hall of the Zapolarye Health & Spa Center
Keynote Session (Invited Lecturers)

AM 11:00 – 12:20
Big Hall of the Zapolarye Health & Spa Center
Combustion Diagnostics - CD
Fundamental Combustion - FC

October 11, 2006

AM 09:00 – 12:20 (Tea break: 10:40 – 11:00)
Big Hall of the Zapolarye Health & Spa Center
Fundamental Combustion - FC

PM 14:00 – 18:00 (Tea break: 15:40 – 16:00)
Big Hall of the Zapolarye Health & Spa Center
Fundamental Combustion - FC
Computational Combustion – CC (16:20 – 18:00)

October 12, 2006

AM 09:00 – 12:40 (Tea break: 10:40 – 11:00)
Big Hall of the Zapolarye Health & Spa Center
Alternative Fuel / Renewable Energy – AF

PM 14:00 – 17:00 (Tea break: 15:40 – 16:00)
Big Hall of the Zapolarye Health & Spa Center
Emission Control - EC

Poster Session

PM 17:00 – 17:40
Big Hall of the Zapolarye Health & Spa Center
Fundamental Combustion - FC
Alternative Fuels an Renewable Energy - AF

Contents

Computational Combustion – CC

Alternative Fuel / Renewable Energy – AF

Emission Control - EC

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

ABSTRACTS

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

About Results of the Numerical Solution of the Hydromechanics Equations

Alexey M. Lipanov

Institute of Applied Mechanics,
Ural Branch of the Russian Academy of Sciences,
Bldg. 34, T.Baramzinoy Str., Izhevsk,
Udmurtia Republic, 426067, Russian Federation
E-Mail: elle@udman.ru

ABSTRACT

In the report the full system of the equations of the hydromechanics for the compressed medium is considered. The non-stationary three-dimensional sub-sonic flow in the flat channel is researched. The range of change of the Reynolds's numbers from 50 up to 10^5 is considered. The symmetric and asymmetrical stationary laminar flows, non-stationary laminar and turbulent flows were analyzed. In the report are presented: the method and the results of the numerical solution of the hydromechanics equations.

In the report is shown, that in the flat sub-sonic channel the kinetic energy of turbulence and the dissipation of the energy have one maximum and then decreases downwards along the flow. The three-dimensional picture of change of the hydro-mechanical parameters is received. In the channel with jump of the cross-section area on its entrance, in the process of moving downwards along the flow, dissipation of the vortex structures occurs. In case of sufficient length of the channel, join of the boundary layers occurs and the cross-section area of the channel is filled with the structures which have generated in the boundary layers. The disturbances propagating in the channel takes away by the flow. In the vicinity of the left boundary the flow has a little noise. The curves describing noise in the vicinity of the right boundary looks like the stationary stochastic functions of the spatial coordinates. Comparison of the results of calculations with the experimental data of other authors has been executed. The intensity of pulsations of the hydro-mechanical parameters, the Reynolds's tangential stresses and the averaged values of the hydro-mechanical parameters were considered. The results of calculations are in good agreement with available experimental data.

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Fundamental Characteristics of Electrostatic Probes as High Resolution Reaction Zone Detectors

Toshisuke HIRANO

President, Chiba Institute of Science
3 Shiomi-Cho, Choshi-Shi, Chiba-Ken 288-0025, Japan
E-Mail: thirano@cis.ac.jp

ABSTRACT
In combustion research, electrostatic probes have been used as detectors of reaction zones of turbulent flames, and a number of novel findings have been made. Since fundamental characteristics of electrostatic probes have not been known, however, the reliability of results obtained in studies using the probes has been sometimes doubted. In fact, extensive studies have been performed by our group to prove the high special and time resolution of the probes appropriately provided. Thus, in the present paper summarized are some selected results of such studies. Based on the measured ion current fluctuation, the special and time resolution of a used probe could be easily inferred. The spatial resolution is less than 0.1 mm and the time resolution is less than 0.1 ms. These high resolutions could be attained only when the electrostatic probes are carefully provided. The diameter of a sensor is recommended to be smaller than 0.1 mm, and the potential applied to the probe should be smaller than 20 V negative against a reference electrode. The sensor should be insulated from other parts of the system. Since a usual insulator of material such as alumina or boron is not effective at a high temperature near the reaction zone, the sensor should be cooled. Thus, the structure of an electrostatic probe should be of a structure with a sensor in an insulation tube covered by a sleeve for cooling. Some results about turbulent flame characteristics explored by using an electrostatic probe are presented. By measuring the times needed for a probe passing across the reaction zone moving in random directions, the reaction zone thickness could be inferred. It is almost equal to that of a laminar flame. Using an electrostatic probe with multiple sensors, the flame front configuration and directions of movements could be measured. Although the direction and velocity of each flame element are random, overall flame front movement is equal to the sum of the unburned gas velocity and burning velocity expressed in a vector field

Keywords: Electrostatic Probe, Turbulent Flame, Time Resolution, Spatial Resolution

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Prediction of the Stability Behaviour of a Combustor using a Low Order Model and Measured Flame Transfer Functions

E. Freitag*, S. Föller and T. Sattelmayer

Lehrstuhl für Thermodynamik, Technische Universität München
85748 Garching, Germany.

ABSTRACT
The stability of modern Low-NOx gas turbine combustion systems is usually assessed using acoustic low-order network models. Since the behaviour of the flame as the dominating source of acoustic energy is not fully understood in theory at the moment, experimental data in form of a flame transfer function (FTF) are often used to implement the flame as an acoustic element into the model.
In the study presented here, experimentally derived flame transfer functions are implemented into an acoustic low-order model of the test rig and the stability predicted by this hybrid model is compared to the actual data measured during rig operation. The results show a good agreement between model and experiment. Also, the trend in the stability behaviour when varying the operating conditions (pressure, thermal power and equivalence ratio) can be captured.
Moreover, an extrapolation of the measured transfer function data has been performed to operating conditions, where no FTF could be derived due to a self-excited combustion oscillation occurring in the investigated regime. By implementing this extrapolated transfer function into the low-order model, the onset of the self-excited instability could be predicted correctly.
Finally, this work shows that operating conditions like pressure or equivalence ratio can have a drastic influence on combustor stability.

*Corresponding author: freitag@td.mw.tum.de

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Reaction Zone Structure in a Stirred Rector with Highly Preheated Methane-Air Premixture

A. Yoshida[1*], H. Naito[1] and D. P. Mishra[2]

[1]Department of Mechanical Engineering, Tokyo Denki University,
2-2 Kanda-Nishikicho, Chiyoda-ku,
Tokyo 101-8457, Japan

[2]Department of Aerospace Engineering, Indian Institute of Technology,
Kanpur, India – 208 016

ABSTRACT
The flame structure at small Damkohler number and large Karlovitz number is still unknown. In the present study, the reaction zone structure in a well-stirred reactor was investigated extensively. The OH-PLIF images suggested that there are no thin laminar flamelets and that the reacting eddies are distributed throughout the reactor. With the cross-correlation of ion signals, the scale of the reacting eddies was determined to be of the order of 4 mm, and the convection velocity of these eddies or zones was found to coincide with the mean flow velocity of the order of 100 m/s. In this combustion regime, NO_X concentration was extremely low and this is very attractive for the practical use to meet the environmental requirements.

Keywords: Turbulent Premixed Flame, Well Stirred Rector, Borghi Diagram, Kolmogorov Scale, Distributed Rection Zone

[*]Corresponding author: yoshida@yl.m.dendai.ac.jp

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

An Experimental Study on Dynamical Behavior of Laminar Premixed V-flames

B. R. Wang*, X. Q. Zhang, W. J. Kong

Institute of Engineering Thermophysics,
Chinese Academy of Sciences
100080 Beijing, China

ABSTRACT

Instability and propagation of flame is an important area for combustion researchers. The ignition and flame-front movements of Turbulent Premixed V-flames were studied experimentally, using methane as fuel. The configuration chosen is an open, rod-stabilized, v-shaped flame propagating in low intensity turbulence. This simple configuration is well suited to basic studies of turbulence-combustion interaction because the flame is free of geometric constraints of the burner, and is devoid of a flame tip as in Bunsen-type turbulent flames. Moreover, incident turbulence is uniform across the flow and the planar turbulent flame sheet can be approximated as two-dimensional. The function of wake flow behind stabilizing rod in ignition was studied. The video of ignition was obtained by high speed camera, which shows that the flame interacts strongly with the wake flow behind the stabilizing rod. The objective of the present study is to carry out an investigation of the relationship between flickering characteristics of premixed turbulent flames and wake flow characteristics behind the stabilizing rod. In contrast to the experiment result, the characteristics of wake flow behind the stabilizing rod were obtained with numerical simulation. The characteristic flickering time scale is about 83ms and spatial scale about 10 mm. The flame flickering frequency is more than 12 Hz, does not comply with the wake vortex shedding frequency, which is about 110 Hz. It is well-known that the flickering of V-flame is affected by both the incident turbulence and the wake flow after the stabilizing rod, but the result shows that the relationship between flickering characteristics and flow characteristics is much more complicated by the chemical reaction. Other factors like buoyancy, thermodiffusive effect, hydrodynamic influence and product expansion should be taken into consideration in further study to enhance insight into the mechanism of flame front instability. On the other hand, precautions are necessary when the rear part of the flame is studied, since potential interaction between flame front and shearing vortex may complicate the concerning problem, if a coaxial sheath flow is not provided.

*Corresponding author: brwang@mail.etp.ac.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Flame Interactions and Stabilization in an Oblique-Impinging Burner

Chih-Chieh Li, Han-Chang Cheng, and Jing-Tang Yang*

Department of Power Mechanical Engineering, National Tsing Hua University
Hsinchu, Taiwan 30043

ABSTRACT
The flame structure resulted from the interactions between two oblique-impinging flames has been experimentally investigated in a novel impinge burner. Various equivalence ratios of propane/air mixture and impinge velocities induced different impinge intensities and created distinct flame modes. The stabilization map of the burner was first categorized via flow visualization techniques; then, the structure of the partial premixed flames was analyzed by using laser-Doppler velocimetry and tiny thermocouples. The results show that the preheat effect dominates the combustion phenomena, including heat releasing rate and molecular diffusion rate. Double-flame interaction increases the flow fluctuation and enhances the mixing rate between the fuel and oxidizer. Two interacting premixed flames response to equivalence ratio oscillations restructure the flow pattern, resulting in unbalanced transports of thermal and mass diffusion. It was found that flame-front instability existed in rich propane/air flame and increased the burning velocity. Heat-release rate is an important parameter to estimate the flame strength. Generally, higher heat-release rate is accompanied by higher temperature fluctuation. Temperature fluctuation is used as an indicator of heat-release rate and flame strength. The maximum temperature fluctuation appeared with two interacting premixed flames, as equivalence ratio is near 1. All these factors raise the temperature of the combustion products, enlarge the stably operating range, and improve the combustion instability of the burners. Quantitative studies on mean flow structure, mean temperature distribution, and flow fluctuations further confirmed the superior combustion mechanism of impinging-burners.

Keywords: Impinging Flow; Stabilization; Flame Interactions

*Corresponding author: jtyang@pme.nthu.edu.tw

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Experimental and Numerical Analyses of Convective Ignition of PMMA in a Sudden-Expansion Channel

F. C. Hsiao, C. H. Chen, Y. C. Lin, and J. T. Yang*

Department of Power Mechanical Engineering, National Tsing Hua University, Hsinchu, Taiwan, R.O.C.

ABSTRACT

Convective ignition and flame spread of a solid fuel slab (PMMA) in a sudden-expansion chamber were investigated at specific inlet conditions u_0 = 3 m/s and T_0 = 1110K. Motion pictures of the ignition transient were acquired via a high-speed CCD camera (1,280×1,024 pixels at 1,000 fps). Spatial and temporal distributions of temperature, velocity, mixture fractions, and burning rate were numerically analyzed by large-eddy simulation (LES) to reveal the control mechanism of ignition and flame spread. Experimental results demonstrate that flame kernels formed and aggregated at the end of the fuel slab is an important source for the ignition on the fuel slab. After the ignition, both concurrent and opposed flame spread were observed. While concurrent flame spread occurs soon after the appearance of the ignition kernel, opposed flame spread usually takes place downstream after a certain time lag (about 0.033s). To ignite the upstream region before the ignition kernels, the flame needs to overcome its energy loss by head-on lash of the shedding vortices to sustain the spreading process. Those flame kernels are found to move in a "rolling" manner, resembling the feature of vortices. Simulation results show that the burning rate of PMMA invariably increased downstream, and it was four times greater at $x = 6.51\ h$ than $x = 2.17\ h$, where h is the step height. The predicted ignition location was in consistent with the experimental observation. Moreover, due to smaller oxygen concentration, no ignition kernel was predicted in the corner region behind the step. Through numerical and experimental results, 3-D features of the mechanisms in ignition and flame spread were revealed. This study provides a new point to the traditional unrecognized ignition and flame spread mechanism.

*Corresponding author: jtyang@pme.nthu.edu.tw

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Combustion Synthesis of TiO_2 Nano-particles with TTIP in A Modified Hencken Burner

H. K. Ma*, H. A. Young and K. T. Lee

Department of Mechanical Engineering, National Taiwan University
106 Taipei, Taiwan

ABSTRACT

Previous studies show that TiO_2 crystal phase purity may be effectively controlled by the oxygen concentration in the Bunsen burner. Under flow rate O_2/N_2=20/80, the weight percent of rutile phase is nearly 100%. On the contrary, it is hard to control the crystal purity phase on the flat burner because of its irregular porous medium. Thus, the modified Hencken burner with regular flow channel, which shown in Fig. 1, is designed with characteristics of the Bunsen burner to control TiO_2 crystal phase purity and particle size for possible mass production. In the modified Hencken burner, the titanium precursor TTIP was fed into the flame by a carrier N_2 flow through a heated TTIP bath. Particles synthesized in the flame were characterized for their morphology, crystal phase purity, and their size, by transmission electron microscopy, and X-ray diffraction. The influence of flame type, flame length, TTIP concentration and O2/N2 molar ratio on crystal phase purity and particle size will be studied in detailed. Under the flow rate O_2/N_2=20/80, the rutile phase of nanoparticle is as high as 96%. Results also show that the size of TiO_2 nanoparticles is highly depending on the TTIP loading and the collecting height in the flame. The range of TiO2 particle size averages from 100nm to 500nm were found under different operation parameters. The modified Hencken burner with shorter flame length is attributed to a decrease in particle reaction time and reduced particle collision frequency in a lower collecting height of the flame.

Keywords: TiO_2 Nano-Particle, Flame Synthesis, Burner, Anatase, Rutile

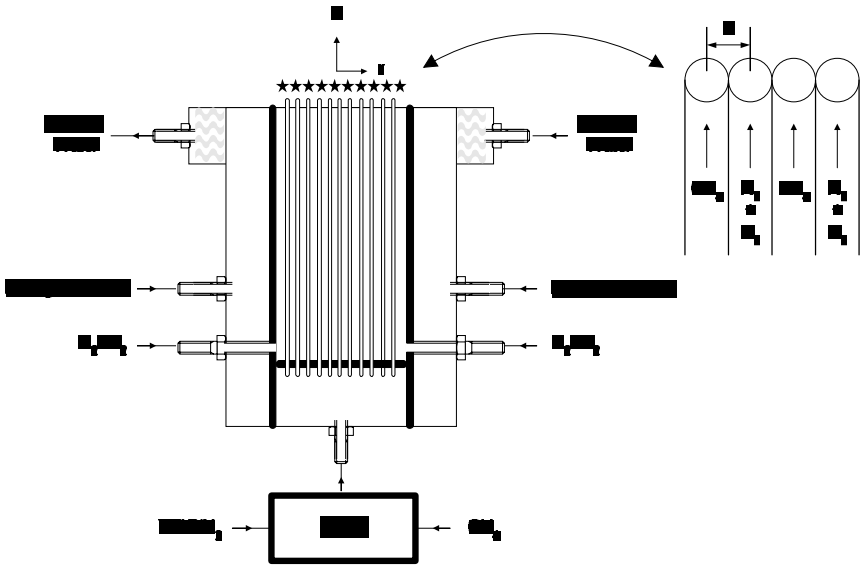


Fig. 1. Modified Hencken Burner

*Corresponding author: skma@ntu.edu.tw

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Multi-Transition Metals (Cr, Cu, Zn, Ni and Co) Modified Zeolite 4A-based Catalysts for Catalytic Combustion of Methane in Mini-Combustor

K.S. Hui and Christopher Y.H. Chao*

Department of Mechanical Engineering,
The Hong Kong University of Science and Technology,
Clear Water Bay, Kowloon, Hong Kong, China

ABSTRACT
Single phase, chamfered-edge and high crystalline zeolite 4A sample was used as catalyst support for multi-transition metals to develop a series of multi-metals (Cr, Cu, Zn, Ni and Co) modified zeolite 4A-based catalysts for the catalytic combustion of methane in mini-combustor. Ion-exchange method was employed to increase the metals loading of the zeolite 4A supports. From XRD analysis, the zeolite 4A structure of the catalysts was still maintained after metals loading. The mean particle size of the catalysts was around 2.3 μm. SEM images of the catalyst showed that the zeolite 4A support was covered with layers of metal elements. The activity of the catalysts for catalytic combustion of methane were studied at atmospheric pressure and total volume flow rate of 10-50 mL/min under different equivalence ratios (0.1-0.4, lean fuel conditions) at 500 ^{o}C. Results showed that the activity of combustion of methane increased with metals loading (wt %) of the zeolite 4A-based catalyst. Combustion efficiency increased monotonically with temperature. Higher combustion efficiency was also achieved by reducing total volume flow rate under the same temperature 500 ^{o}C. The apparent activation energy of the catalyst (119 kJ/mol) was deduced which was comparable to other types of zeolite-based catalysts in the literatures (98-196 kJ/mol). Results indicated that the catalyst performed better at lean fuel conditions.

Keywords: Catalytic Combustion, Combustor, Zeolite, Metals, Methane.

*Corresponding author: meyhchao@ust.hk

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Experimental Study on the Lift-off Characteristics of Triple Flames with Fuel Dilution

Jeong Il Seo[1*], Nam Il Kim[2] and Hyun Dong Shin[1]

[1]Mechanical Engineering, KAIST, Republic of Korea
[2]Mechanical Engineering, Chung-Ang University, Republic of Korea

ABSTRACT
The effects of fuel dilution on the lift-off characteristics of triple flames were studied experimentally using a multi-slot burner, which can stabilize the lift-off flame especially at weak fuel concentration gradients. Contribution of diffusion branch to the propagation velocity of triple flame was examined by employing three kinds of fuel compositions diluted by nitrogen (0%, 25%, 50% N_2). Lift-off height, axial velocity variation, and OH radical are measured by various laser diagnostic methods (ICCD camera, PIV system, OH-LIF etc.). Fuel dilution reduced the propagation velocity of triple flame mainly due to the decrease of flame temperature in premixed branch, and resulted in a significant change in flame stabilization conditions. OH radical in the diffusion branch is not clearly observed behind the premixed branches at very weak fuel concentration gradient, but becomes prominently active at the specific fuel concentration gradient. Despite the difference in fuel dilution, lift-off heights of triple flame have minimum value during the increase of fuel concentration gradient resulting in U-shaped trends. This fact means that the propagation velocity has a maximum value at a specific fuel concentration gradient regardless of the fuel dilution even though the critical concentration gradient varies. The enhancement of the OH radicals near the maximum propagation velocity was more clearly detected in higher dilution case. Thus the effect of the diffusion flame on the propagation velocity of triple flame needs to be reconsidered.

[*]Corresponding author: seoji@kaist.ac.kr

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Ranges of Supersonic Combustion Rates in a Porous Medium

M. Mbarawa[1*], S. A. Zhdanok[2], P. N. Krivosheev[2], and O. G.Penyaz'kova[2]

[1]Department of Mechanical Engineering, Tshwane University of Technology,
Private Bag X680 Pretoria 0001, South Africa;
[2]V. Luikov Heat and Mass Transfer Institute, National Academy of Sciences of
Belarus, 15 P. Brovka Str., Minsk, 220072, Belarus

ABSTRACT

Recently, there is a huge interest in the study of processes of combustion propagation and detonation in porous media (PM) and blocked up spaces (BS). This is due the development of new technologies based on filtration combustion and unsolved problems of explosion safety in different branches of industry. It is known that the velocity of the denotation wave propagating in a porous medium is lower than the Chapman–Jouget detonation velocity in a free tube, and this difference increases with decreasing initial pressure of the gaseous air fuel mixture. The mechanisms of ignition initiation and combustion wave propagation in PM differ considerably from the combustion in a free space, since a PM is characterized by a much larger hydrodynamical drag coefficient, stronger gas flow turbulence and greater heat losses and, therefore, in the reaction wave propagating in a porous media, the energy losses from the flame front are much more significant that the normal flame in a free space. In general, the mechanism of propagation of fast combustion waves in a PM incorporates the elementary processes of convective energy transfer, diffusion, and heat exchange between the gas and the porous media solid bodies. However, these processes are still not clearly understood. Moreover, the mechanism of mixture ignition in the interpore space is not clearly understood either. It is believed that at lower velocities ignition initiation occurs due to the penetration of the burning gas from the nearby pores, the flame-front acceleration under interaction with reflected shock waves, and the spontaneous ignition of the compressed mixture. With increasing velocity, the gas ignites mainly as a result of the adiabatic compression after the reflected shock waves. At present, there is no detailed theoretical description of the processes of porous combustion that would permit a priori prediction of the flame velocity depending on the PM characteristics and the initial pressure. To develop such a model and check its validity, one needs a set of experimental data varying over a wide range of change in the basic parameters. However, currently there are very few experimental data on the supersonic combustion in porous media. The aim of the present paper is to measure supersonic combustion of the stoichiometric acetylene–oxygen mixture with various degrees of dilution with nitrogen at different initial conditions. The experiments were performed using two steel detonation tubes with an inner diameter of 25 and 50 mm and a length of 5 and 1.2 m, respectively. Both tubes were equipped with photo-and ionization sensors to register the arrival time of the flame front and the velocity of its propagation along the tube axis, as well as with piezoelectric sensors to measure the pressure and the velocity of the leading shock wave front. The results of the study reveal that there are different regimes of combustion in a tube partially filled with a porous medium. Furthermore, the results also show that the combustion wave velocity was from 0.3 *V*C–J in the less sensitive acetylene–air mixture near the propagation boundary to up the detonation velocity in the acetylene–oxygen mixture at a high pressure.

[*]Corresponding author: mmbarawamm@tut.ac.za.

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Investigation and Improvement on Performance of a Porous Medium Burner with Reciprocating Flow

M.Z. Xie*, J.R. Shi, Y.B. Deng, L. Zhou

School of Energy and Power Engineering,
Dalian University of Technology
Dalian 116024, China

ABSTRACT
Experimental and two-dimensional numerical investigations on the structure improvement of porous inert media burner with reciprocating flow are presented. Attention was focused on the combustion temperature and pressure loss in the burner, which was respectively packed with 10ppi ceramic foams or alumina pellets with various sizes. Results show that material and structures of porous media have significant influence on the burner performance, and that ceramic foam with high porosity is suitable for using in the combustion region whereas alumina pellets should be placed in the heat exchange zone. According to this principle, an improved burner design is proposed and this leads to a wider high temperature profile and moderate pressure loss for extremely dilute CH4/air mixture with an equivalence ratio of 0.1. Numerical results are validated against experiment data.

Keywords: Performance; Porous Medium Burner; Reciprocating Flow; Super-Adiabatic Combustion

*Corresponding author: xmz@dlut.edu.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Bluff Body Effect on the Stabilization of Premixed Flame

M. Abdul Wahid[*] and M. N. Abu Bakar

Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia,
81310 UTM Skudai, Johor, Malaysia

ABSTRACT
The effect of bluff body on stabilization of liquid petroleum gas (LPG) - air premixed burner flame has been experimentally investigated. One of the objectives of this experimental work was to perform an analysis on the effect of the bluff-body shape on flame stabilization. A method of aerodynamically stabilizing lean premixed natural gas flames on a conventional burner was investigated. The analysis of premixed flames stabilization process was focusing mainly on the shape and sizes of flame holders. To study the influence of the bluff-body shape on the stabilization process, four flame-holders were considered: a rod, a wire and rings of several diameters. Flames were anchored in the wake behind a small ring placed in the exit plane of a conventional burner. The stabilization conditions were based on the description of the stability domain and of the characteristic flame modes. Direct visualizations allow a better knowledge of these different regimes: laminar stable flame, transition and unstable flame. An aerothermodynamic description of the reacting flow in the bluff-body wake was performed over a range of Reynolds numbers and mixture equivalence ratios.
The objective was to extract from this analysis, the differences in the flame structure due to the bluff-body geometry and their consequences on the stabilization diagram. Results show the existence of various types of flames, according to the classical premixed burner flame, but the influence of the bluff-body shape on these stabilization regimes is also demonstrated. Comparison between the flow without bluff body and with bluff body on flow as well as flame stabilization was discussed. It was found that the stabilization of the flame is improved by having bluff bodies on downstream of the flow. Without bluff body the stability region of the flame is limited or in general the flame is easier to blow off and flashback. The overall with bluff body stability regime of the burner was significantly increased, permitting stable lean premixed combustion. The influence of the ring with different diameters on flame stability limit was also investigated.

Keywords: Bluff Body, Stabilization, Premixed, Flame

[*]Corresponding author: mazlan@fkm.utm.my

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Numerical Investigation on the Interactions Between a Fuel Spray and a Hot Porous Medium

Maozhao XIE[*] and Zhiguo ZHAO

School of Energy and Power Engineering,
Dalian University of Technology, Dalian 116024, China

ABSTRACT

To gain a deep understanding of process of the fuel/air mixture formation and the role of porous medium (PM) in the mixture homogenization and combustion in a PM engine, the interactions of fuel spray and a hot porous medium were investigated computationally by using a modified engine CFD code KIVA-3V with an improved spray/hot wall interaction model. This improved model is fitted into the regime above the Leidenfrost temperature to account for the engine working condition, and is capable to predict the properties of the post-impingement fuel droplets and the heat transfer between fuel droplets and a hot surface. The porous medium with high porosity was simulated with a simplified two-dimensional model, in which the complex structure of PM was represented by an array consisted of a number of small square-formed blocks. The fuel spray was described by the discrete droplet method (DDM). The injection, movement, vaporization of the fuel droplets in the open space and inside the PM and their impingement on the block edges were computed. Comparison of the computational results with experimental data from the literature show a qualitative agreement. Influences of operating parameters, including ambient pressure, nozzle position and spray cone angle on the characteristics of fuel spray and mixture formation are discussed based on numerical results.

Keywords: Spray/Hot Wall Impingement Model; Ambient Pressure, Spray Injection Position, Spray Cone Angle

[*]Corresponding author: xmz@dlut.edu.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Quantitative Estimation of the Static and Dynamic Parameters of Jet A-air Detonation from the First Principle Calculations

M.I.Strelkova [1*], I.A.Kirillov[1], B.V.Potapkin[1,2], S.Ya.Umanskiy[2,3], A.A. Bagatur'yants[2,4], A.Safonov[2,4], V.V.Liventsov[1], M.A. Deminsky[1], T.Dean[6], B.Varatharajan[6], A. Tentner[7]

[1] RRC Kurchatov Institute, Moscow, Russia
[2] Kinetic Technologies Laboratory, Moscow, Russia
[3]N.N.Semenov Institute of Chemical Physics, Moscow, Russia
[4]Photochemistry Center, Russian Academy of Science, Moscow, Russia
[5] M.V.Lomonosov Moscow State University, Russia
[6]GE Global Research, Niskayuna, USA
[7] Argonne National Laboratories, Chicago, USA

ABSTRACT

Combustion of the Jet A aviation kerosene surrogate (72.7% n-decane + 9.1% n-hexane + 18.2% benzene) at high temperatures (1000 – 2000K) was modeled. The construction of the detailed chemical mechanism based upon available in literature chemical mechanisms of n-decane [1], n-hexane [2], and benzene [3] combustion. Rate constants of the elementary reactions were verified. This verification was based upon most recent compilation of rate constants of reactions important in combustion [4], qualitative physical and chemical arguments (e.g spin conservation, characteristic orders of magnitude of preexponential factors), thermo chemical data, and also upon similarities between reaction centers in different hydrocarbons. The performed analysis showed the necessity of the first principle study of several classes of reactions based upon modern quantum chemistry and microscopic theory of chemical reactions. This is especially important for the initiation reactions (these reactions determine the induction time) which cannot be studied in direct experiments due to there high activation energies. Such first principle calculations were performed for the H abstraction reactions of O_2 with C_6H_6, C_2H_6 and C_3H_8 and OH with C_2H_6 and C_3H_8. Package of quantum-chemical programs GAUSSIAN [5] together with the modules KHIMERA [6] and CARAT of the integrated program package for kinetic calculations CHEMICAL WORKBENCH [7] were used. The results obtained were extrapolated for the higher alkanes using Benson similarity group method [8]. Validation of the developed detailed mechanism was carried out using CHEMICAL WORKBENCH program package. The static (Chapmen-Jouguet, von Neumann parameters) and dynamic (ignition delay time, induction length in ZND model) parameters were calculated as function of temperature (1000<T<2000 K), pressure (1<P<100 atm) and equivalence ratio 0.5-1.5. It is shown the capability of the 3-component Jet-A surrogate fuel to predict the ignition delay times for Jet A fuel, as well as temperature and species concentrations time histories over wide ranges of temperature and pressure.

1. Bikas G., Peters N.,Combustion and Flame 126, 1456 (2001).
2. Curran H.J.,et al Combustion and Flame 114,149 (1998).
3. Dinaro J.L., et al Proceedings of the Combustion Institute 28, 1529 (2000).
4. Baulch D. L. et al J. Journ. Phys. Chem. Ref. Data 34, 757 (2005).
5. M.J. Frisch, et al GAUSSIAN98, Revision A.3, Gaussian Inc., Pittsburgh, PA, 1998.
6. Novoselov K.P., et al J. Comp. Chem. 23, 2366 (2002).
7. Deminsky M., et al Computational Materials Science 28, 169 (2003).
8. Benson S.W. Thermochemical kinetics. Wiley, New York (1976).

[*]Corresponding author: strelkova@hepti.kiae.ru

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Flow and Heat Transfer Analysis on Spiral Counter Flow Heat Re-Circulating Burner

M. Abdul Wahid*, K. Osman, M.F. Othman

Department of Thermo-Fluids, Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia, 81310 UTM Skudai,
Johor, Malaysia

ABSTRACT
In order to establish a performance characterization of spiral counter flow heat re-circulating burner, an understanding of the chemical kinetics, heat transfer and flow dynamics aspects of the combustor needs to be developed. This paper would be focusing on the micro-scaled square spiral counter flow configuration which is also known as the "Swiss roll" micro-combustor with propane-air mixture as the case study. A two-dimensional Computational Fluid Dynamics (CFD) with propane-air premixed stoichiometric numerical based model is being adopted and focus of the study would be in observing the thermal characteristic (i.e. heat recirculation rate) of the combustor. This is the parameter that characterizes the preheat energy obtained by the incoming reactants through combustion process and its high energy post-combustion products. The performance of the combustor with respect to the thermal characteristic is being analyzed at a range of $40<Re<1000$ steady, laminar and incompressible fluid flow velocity profile. In addition, a parametric study on identifying the effect of different geometrical aspect ratio between channel wall thicknesses to channel width is also being investigated. Analysis has shown that a heat recirculation method has managed to produce an excess enthalpy flame beyond the adiabatic flame temperature which leads towards extending the limitation of the combustion process feasibility in a miniaturization of a combustor system.

Keywords: Re-Circulating Burner, Micro-Combustor, Heat Transfer, Spiral Counter Flow

*Corresponding author: mazlan@fkm.utm.my

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Research on Fire Initiation in Manned Space Vehicle by "Function Simulation" Method

X. Q. Zhang[1] *, L. F. Cheng[1] and Z.S. Tian[2]

[1]Faculty of Institute of Engineering Thermophysics, Chinese Academy of Sciences, 100080 Beijing, China.

[2]Faculty of Graduate School, Chinese Academy of Sciences, China.

ABSTRACT

Fire safety is one of the most important problems which must be solved properly for the manned space flight since it is closely related to the safety of astronauts and the success of the flight mission. Combustible materials (non-metallic materials), Oxygen and igniter are the three necessary elements for fire. Although each one of the three elements is equally important the experiences of manned space flights show that the igniter made much trouble frequently. The electric wire, cable and components are the potential igniters it might cause fire under certain unexpected circumstances. In order to eliminate these potential igniters as much as possible a series of extremely strict qualification tests have been set up. But all these tests have been conducted on the ground. Since the heat transfer is quite different in space (microgravity) from on the ground. One has to pay much attention to these differences very carefully. It is almost impossible to get long time (for example several minutes, several hours) microgravity condition on the ground. Several simulation methods have been proposed to solve this problem. Each one has its own limitation. The problem to simulate long time microgravity condition on ground still keeps unsolved up to now. A function simulation method has been proposed in the present paper. The natural convection almost vanished at microgravity. The heat transfer of the electric components is quite different at microgravity from on the ground. The concept of "function simulation" means that the simulation is satisfied in heat transfer sense. Based on the fundamental governing differential equations of the heat transfer. By the use of theory of similarity as long as the similarity modulus Nusselt number equals everywhere the simulation of heat transfer is satisfied. For natural convection the Reynolds number is no longer an independent similarity modulus, only the Grashof number equals everywhere the velocity field will be similar. Meanwhile, in the present case the prandtl number of air is almost a constant which dose not vary with its temperature and pressure. The prandtl number describes the inherent relationship between velocity field and temperature field. So, provided the Grashof number equals everywhere, the Nusselt number will also be equal everywhere. That means the simulation of heat transfer is satisfied. Based on this concept by selecting different pressure (i.e. different density) to simulate different gravity level, a series of experiments have been conducted. The experiment results verified clearly that the concept "function simulation" is a very effective method to simulate the heat transfer process of the electric components at microgravity. The experiment results also indicate that at microgravity the natural connection almost vanished, the heat loss of the electric components decreased, it might cause the over heat of the electric components and then result in fire. The space experiments are in progress.

Keywords: Function Simulation, Fire Safety, Manned Space Flight, Microgravity, Electric Components

*Corresponding author: zxq@mail.etp.ac.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Reverse Engineering on Laser Ablation of YSZ

Y. S. Ouyang

Faculty of BioIndustrial Mechronics Engineering,
National Taiwan University
1, Roosevelt Road, Section 4 (106),
Taipei, Taiwan
E-Mail: ouyang@ntu.edu.tw

ABSTRACT
Applying low cycle pulsed laser to process Yttrium stabilized zirconia (YSZ) for ascertaining porous surface topology involve complex thermal physical phenomena and adverse effects. They concern very much with materials specific mass-energetic interactive mechanisms in spatial and temporal domains underlain by a confined volume of lattice structure that is expanding from solid state to condensed phase then to gaseous plasma states on the order of nano second time scale, nominally. Governing theories span from quantum to continuum mechanics. Under piecewise energy equilibrium assumption, we developed a simplified thermal physical model of mesomechanics and used it to evaluate processing characteristics implementing an inverse engineering approach, where experimental results were characterized in establishing virtual design objective. Our aim is to establish a unified scheme in facilitating processing system configuration design which often links with strategic capital investment problems particularly when energy conservation and ecology cleanliness are becoming salient issues in high energy density rate manufacturing technology sector. Results and pending issues will be discussed.

Keywords: Pulsed Laser, Selective Ablation, Porous YSZ, Reverse Engineering, Meso-Mechanics

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Pulse Combustion of Hydrocarbon Fuel

M.Abdul Wahid*, M.H. Ujir, and A. Zahar

Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia,
81310 UTM Skudai,
Johor D.T, Malaysia

ABSTRACT
This paper investigates pulse combustion process operated with liquefied petroleum gas (LPG). The main concern of this paper is to study the nature of pulse combustion leading to detonation of oxygen – hydrocarbon gaseous mixture in a rounded straight tube. Liquid petroleum gas was used as fuel which consists of mainly propane and butane in composition around 40 and 60%, respectively. The main parameter measured was the velocity of combustion wave propagation. Experiments were conducted using two configurations; with and without obstacles. The obstacles were used in order to accelerate the combustion wave propagation via deflagration to detonation transition process (DDT). There were three types of obstacles; spiral, orifice A of 0.55 area ratio blockage and orifice B of 0.38 area ratio blockage. The experiments have shown that propagation of combustion wave was successfully accelerated to higher velocities for about 1.08 times for spiral, 1.23 times for orifice A and 1.18 times for orifice B.

Keywords: Pulse Combustion, Deflagration to Detonation Transition (DDT), Obstacle, Combustion Wave, Hydrocarbon.

*Corresponding author: mazlan@fkm.utm.my

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Effects of Oxygen Concentration on the Combustion Characteristics of Interacting Coal Particles

Chong Pyo Cho, Sang Phil Jo, Ho Young Kim*, Sam S. Yoon and Yongchan Kim

Department of Mechanical Engineering, Korea University.
5-ga, Anam-dong, Sungbuk-gu,
Seoul, Korea

ABSTRACT
The laminar combustion characteristics of coal particles at various oxygen concentration levels of a surrounding gas have been numerically investigated in 2D coordinate. The numerical simulations, which accounts for the surrounding gas effect using the two-step global reaction model, include the detailed interaction among the inter-spaced particles, undergoing devolatilization and subsequent char burning. Several parametric studies, which include the effects of the gas temperature (1700 K), oxygen concentration, and variation in geometrical arrangement of the particles on the volatile release rate and the char burning rate, have been carried out. To address the geometrical arrangement effect, multiple particles were located with an inter-spacing of 2-10 particle diameters. The results for the multiple particle case were compared with those for the single particle case. The comparison indicated that the shift to the multiple particle arrangement resulted in affecting the combustion characteristics substantially; the volatile release rate of interacting coal particles exhibits a strong dependence on the decreasing particle spacing at lower oxygen concentration when convective heat transfer effect was enhanced. The char combustion rate is controlled by oxygen diffusivity level and gas composition near particles during the combustion, and highly depends on the particle spacing for all the oxygen concentrations.

Keywords: Interacting Coal Particles, Volatile Release Rate, Char Combustion, Oxygen-Enriched Combustion

*Corresponding author: kimhy@korea.ac.kr

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

To the Kinetics of the Reaction of Porous Carbon Particle with Steam

V. M. Gremyachkin

Institute for Problems in Mechanics RAS ,
101/1 ave. Vernadskogo, 119526 Moscow, RUSSIA
E-Mail: grema@ipmnet.ru

ABSTRACT
The kinetic model of porous carbon particle gasification in steam is developed. The model considers the processes of heat and mass transfer both inside the porous particle and outside the particle in gas. Heat losses by radiation from the particle to furnace are taken into account. The heterogeneous reactions of carbon with steam and carbon dioxide and homogeneous reaction of carbon monoxide with steam are considered in the model. It is shown the curve of the dependence of the rate of the particle gasification on the particle surface temperature has to belong to the narrow domain in what the concentrations both carbon dioxide and carbon monoxide are positive values. The analysis of the model inside the porous particle gives the possibility to determine the correlation between rate of the reaction of carbon with steam and the rate of the reaction of carbon with carbon dioxide.

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Flexible Shaped-Charge Cutter

Yu. A. Vedernikov and B. P. Kryukov

Institute of Computational Mathematics and Mathematical Geophysics,
SB RAS, Novosibirsk 630090, Russia

ABSTRACT

A shaped charge containing a flexible metallic shell filled with explosive substance, a longitudinal wedge-type shaped-charge groove with a metal layer, and a charge initiation device. Its characteristic feature is that the shell has undulating flutes with the amplitude and period of sinusoid ranging from 0.05 to 0.15 and from 0.1 to 0.3 of the shell diameter respectively, whereas one longitudinal wedge-type shaped-charge groove is made stepwise with the angles at the vertex of steps not less than 45º and the upper vertex in the plane of symmetry of the shell. At the same time there are transversal pyramidal grooves with the number of sides not less than three, with the height less than the distance from the vertex of the groove to the shell located at a distance of 2 to 5 diameters of the circle described round the polyhedral base of the groove made along the entire length of the wedge-type groove. A computer modeling of the functioning of the flexible shaped-charge cutter wound round an oil-well drill with grooves directed towards the oil-bearing strata was performed for the filling of explosive substance made of ammonium sulphate particles. A 1.5 times increase in secondary oil production has been shown as compared with the prototype described in paper [1].

REFERENCES

1. Kholod V., *Choosing a Strategy for Secondary Development,* FEC Technologies, 2005, #5

2. Tarasov V. I., Yanilkin Yu. V., Vedernikov Yu. A., *Three-Dimensional Numeric Investigation of a Shaped-Charge with Star-Shaped Lining,* PCE, 2000, #6

3. Ogureikin V. A., Kryukov B. P., *The Method of Individual Particles to Calculate Currents of Multicomponent Media with Large Deformations*, Numeric Methods of CMM, Novosibirsk, 1986, vol. 17

Keywords: shaped charge, oil-well drill, method of individual particles

*Corresponding author: Yuveder@omzg.sscc.ru

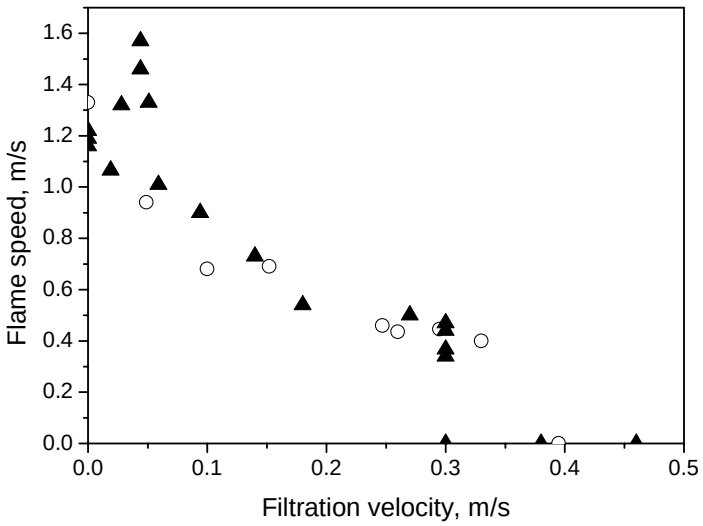
8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Filtration Gas Combustion Under High Velocities

V.S.Babkin[1*], A.A.Korzhavin[1], I.G.Namyatov[1], V.I.Drobyshevich[2], Yu.M.Laevsky[2]

[1]ICK&C SBRAS, Novosibirsk, 630090, Russia
[2]ICM&MG SBRAS, Novosibirsk, 630090, Russia

As was shown earlier experimentally, the combustion in porous media proceeds via several modes characterized by typical flame propagation velocity (u): LVR, low velocity regime (u~1-0.1 mm/s), HVR, high velocity regime (u~1-10 m/s), and detonation regimes.. In the work presented, the gas combustion under high rate of combustible gas flow in the porous media typical for HVR was studied. Flame propagation under conditions of counter flow flame propagation was analyzed in the channel filled with steel balls as the porous medium under steady flow of combustible mixture. The correlation between flame propagation and filtration velocity is shown in the figure.. As seen, the flame propagates in the motionless mixture (v=0) with rather high speed (u>100 cm/s). As filtration velocity is increased the flame speed decreases. If it achieves the value (v~30 cm/s), the flame propagates in LVR. The property of stabilization of flame under high flow velocities was applied in two-layer porous burner. In this burner, the flame front is stabilized in the layer typical for HVR. The correlation between radiation flux, temperatures at various layers of the porous media and the flow velocity of combustible mixture were estimated. The working capacity of the burner was demonstrated within a wide range of power, from 1.7 to 18.7 kW (specific heat load up to 0.8 kW/cm^2). The stabilized flame could be produced in the burners with divergent flow. By using simulation, we have estimated the temperature distribution in the gas and porous media; positioning of stabilization; width of the wave front, and other combustion parameters for the cylindrical burner.



Flame propagation speed vs filtration velocity. Porous medium is steel balls with diameter d, stoichiometric mixtures with air; ○-propane, d=9.5mm, ▲-methane, d=12.7mm.

This work was supported by the Program "Energy-saving SB RAS-2006" and RFBR (grants 06-03-32524, 05-03-98000).

*Corresponding author: babkin@kinetics.nsc.ru

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

The Burning Behaviors of Collision-Merged Water/Diesel, Methanol/Diesel and Water+Methanol/Diesel Droplets

C. H. Wang*, K. L. Pan, L. J. Kung, and W. H. Huang

Department of Mechanical Engineering
National Taiwan University
Taipei, Taiwan, Republic of China

ABSTRACT
The combustion characteristics of freely falling droplets, individually generated by the merging of colliding water/diesel, methanol/diesel, and water+methanol/diesel droplets, were investigated. The merging of water and diesel droplets was manifested in insertive mode, in which water droplet inserted into diesel under all the test conditions; methanol droplet adhered to diesel as its size was relatively smaller than diesel and might enclosed diesel droplet as its size was large; and water+methanol droplet inserted into diesel as water fraction in water/methanol mixture was >0.8 and adhered to diesel for the rest. Occasionally, air bubbles were found to be trapped at the colliding interfaces, induce heterogeneous nucleation of water, methanol and water+methanol; and consequently, the droplet exploded after a short time upon ignition. For the merged water/diesel droplets, since water droplet was enclosed by diesel, the only vaporized diesel led to almost unchanging in flame color during the burning periods and the droplets terminated with either extinction or flash vaporization. For methanol/diesel droplets, as methanol fraction is lower than ~0.4, consistent, irregular explosion occurred shortly after ignition; and those with higher fraction of methanol, since diesel droplet was enclosed by methanol, the only vaporized methanol led the flame almost invisible after ignition, and a regular, delayed, explosion occurred some times after the flame changing its color to yellowish. As for water+methanol/diesel droplets, the flame color was similarly to that of water/diesel droplet during its regular burning periods, that indicating the original adhesive merging droplets was changed to inserted mode during the burning. The colliding droplets also terminated with either extinction or explosion, but with altered extinction limits and explosion behaviors. In light of the difficulty of forming stable methanol/oil emulsions, the potential of separate injection of methanol/oil or water+methanol/oil in opposed jet arrangement, in direct-injection engines, is suggested.

Keywords: Collision-Merged Droplet, Explosion, Extinction

*Corresponding author: chinghua@ntu.edu.tw

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Effect of the Injector Shape on the Stability and Structure of Co-Flowing Jet Diffusion Flames

Yoshinobu Kotani* **and Akira Yoshida**

Department of Mechanical Engineering, Tokyo Denki University
Addresses : 2-2 Kanda-Nishikicho, Chiyoda-ku,
Tokyo 101-8457, Japan

ABSTRACT
The jet diffusion flames are widely used in practical combustors. Therefore, many experimental and theoretical studies have been actively conducted. This paper is intended to investigate the effect of fuel flow fluctuations (the induced turbulence inside the injector) on the stability behavior from the viewpoint of fundamental study. It has not yet been sufficiently elucidated. In this experiment, the stability and structure of the jet diffusion flame developing in a coaxial flow burner, as well as the pipe flow characteristics have been investigated using two type injectors with the different inlet shape (term, orifice and bell types). The variable parameters are the fuel velocity, *Uf*, the air velocity, *Ua*, and the thickness of injector rim, δ. The results indicates that the critical value *Re* (*Re,c*=11,000) of the bell type injector is about 5 times larger than that of the orifice type (*Re,c*=2,200), and the induced turbulence is also small compared with the orifice type. In addition, the flame configurations and stability limits for each injector are quite different. They are extremely sensitive to the parameters (*Uf, Ua,* δ). For the bell type injector, four types of stability limits were observed depending on the parameters. The first one is the blow off or the lift off of the attached and the rim flames, and is strongly influenced by the δ. The second one is the local extinction at the transition point from laminar to turbulent flame. The third one is the complete extinction at the transition region, in which laminar flame is separated from turbulent flame (split flame). The final one is the extinction of the turbulent diffusion flame. Beyond the limits, the turbulent portion of flame can never be stabilized, and only the short laminar flame remains at the injector, and most of the injected fuel flows downstream without combustion (rim flame). It is very interesting in relation to safety. In contrast, the orifice type injector was observed only the blow off or the lift off of the attached flame. Then various phenomena related to the respective flame configurations are discussed.

*Corresponding author: kotani@cck.dendai.ac.jp

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Torch Combustion and Low-Frequency Non-Acoustic Combustion Instability Phenomena in Solid Propulsion Physics

Alexander N. Lukin

Department of Mechanics & Physics-Chemistry of Heterogeneous Mediums
Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences
Izhevsk, 426067, Udmurtia Republic, Russian Federation,
E-Mail: udman@mail.ru

ABSTRACT

Understanding of the mechanism of the low-frequency non-acoustic instability phenomena at the solid rocket propellants combustion - one of the most complicated problems in the solid propulsion physics. The burning process of each specific solid propellant can be characterized by the set of own frequencies of pulsations of the burning surface that appears in the critical burning conditions. Several theories have been proposed highlighting one or other process as the dominant mechanism, but a unifying theory is yet to emerge. The present work focuses on one of the critical events, namely the spatial-periodic micro-structures (SPMS) excitation in the evaporated energetic materials (EM) liquid-viscous layer (LVL). The low-frequency non-acoustic combustion instability phenomenon, the chuffing phenomenon and the accompanying physics-chemical effects have received a new explanation within the concept based on the data of optical visualization of the physics-chemical processes on the EM burning surface. This concept connected, mainly, with excitation of the synergetic dissipative SPMS in the thin LVL and on the EM burning surface. At heating from above in the thin LVL occurs the thermo-electric convection excitation, that induce cellular movement and formation of the synergetic SPMS. On the EM burning surface is observed the process of self-organizing of the dynamic dissipative synergetic SPMS into the torch macro-structures. Suggested mechanism opens possibilities for understanding the essence of the EM unstable combustion phenomena on the new qualitative level.

Keywords: Evaporated Energetic Materials, Combustion Instability, Chuffing, Torch Macro-Structures, Ionic Fusion with Thermo-Electric Properties, Carbon Grid

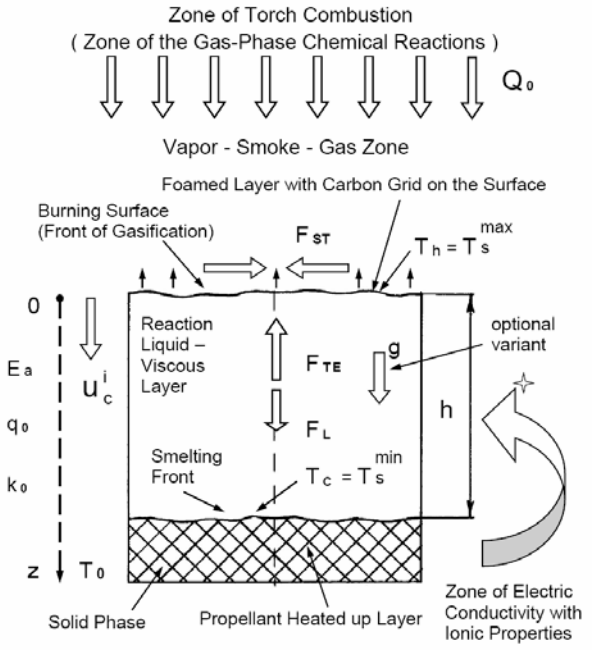


Fig. 1.

Fig. 1. Thin liquid-viscous layer in the EM reaction zone, having thermo-electric properties at heating from above

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Segregating Role of Convection on Gas Phase Auto-Ignition in a Closed Explosion Sphere

I.A. Kirillov[1*], I.A. Zaev[1], A.V. Panasenko[2], S.A. Vasil'evsky [3], H. Pasman[4]

[1]Kurchatov Institute, Moscow, RU;
[2]Central Institute of Machine Building, Korolev, RU;
[3]Institute of Applied Mechanics, Moscow, RU;
[4]Delft University of Technology, Delft, NL

ABSTRACT
Auto-ignition of gaseous combustible mixtures is a typical multi-physics phenomenon, where processes of different nature interplay in a complex manner. A set of experimental observations during auto-ignition in a widely used engineering tool – a closed explosion sphere - testify, that physical processes (heat- or mass-transfer, turbulence, buoyancy) can be equally important as chemical ones (heat release, species generation or consumption). However, a clear and coherent physical picture of synergetic action of both chemical and physical effects, as well as an understanding of relative importance of the separate physical effects are still absent. This report presents the results of numerical simulations of auto-ignition in a closed explosion sphere with heated walls. The goal is to understand the basic patterns of convective flows, induced by chemical heat release and modified by thermal flux from walls and buoyancy under gravity. For systematic studies of the heat transfer effects (thermal conductivity, convection) on auto-ignition, the governing equations for multi-species, viscous, thermally conducting, compressible, reactive gas dynamics in the presence of the gravitational field have been rewritten in non-dimensional form. The results of the parametric simulations permit 1) to delineate the basic reactive gas-dynamics patterns, which emerge and evolve during auto-ignition, 2) to reveal regimes, where the use of a simplified heat loss model yields large deviations from results of simulation of more rigorous models. Acknowledgment: This work was performed under financial support of the Dutch-Russian project 04-07-08029 "Multi-fold Computer-Aided Analysis and Computational Modeling of the Multi-Stage Ignition Processes", sponsored by the NWO (NL) and the RFBR (RU).

[*]Corresponding author: kia@hepti.kiae.ru

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Two-Step Hydrogen Combustion Model for Best Estimate Modeling of Hydrogen Safety

I.A.Zaev , I.A.Kirillov*

RRC Kurchatov Institute, Moscow, Russia

Safety of the hydrogen installations and devices is vitally important for smooth transition to hydrogen-based economy. For proper modeling of the hydrogen-related hazards (flames, detonation) and design of the inherently-safe devices it is necessary to have a thoroughly validated chemical kinetic model, which, on the one hand, has a wide range of applicability, on the other hand – be as computationally fast as possible. Report presents the results of kinetic model development, performed in the Hydrogen Energy and Plasma Technologies Institute. Review of the state-of-art in experimental studies of hydrogen ignition is performed. The basic peculiarities of hydrogen-air ignition are delineated for a wide range of practically important parameters (pressure, temperature, equivalence ratio). Short overview of the existing reduced kinetic models for hydrogen combustion is made. Physical background of the proposed model is explained. The results of kinetic (0-dim) and CFD (1- and 2-dim) validations are discussed.

*Corresponding author: kia@hepti.kiae.ru

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

On the Modeling of Density Gradients with the Wave Equation for the Analysis of Combustion Instabilities

E. Wanke[*] and T. Sattelmayer

Lehrstuhl für Thermodynamik,
Technische Universität München
85748 Garching, Germany.

ABSTRACT

In order to reduce the NO_x-emission of pollutants, modern combustion systems mostly operate in the lean and premixed mode. However, premixed combustion is known to be prone to combustion instabilities. Due to the lack of appropriate design codes the thermoacoustic stability of turbulent flames within complex geometries can not be earlier investigated than in very late development stages of new engines, commonly by costly experiments. As no commercial tools are available for the stability analysis of gas turbine combustors, the development of better numerical models is an open research task. In order to improve the current situation, a numerical model is developed, which employs a commercially available finite-element tool and uses self-defined functions representing the physical processes. The model is based on the wave equation, extended by a source term coupled to the acoustic field, which models the driving due to periodic heat release. In the past the wave equation for homogeneous media was almost exclusively used in numerical investigations of acoustic wave propagation in combustors with flames and strong density gradients. The errors associated with this approach are investigated. For this purpose the results obtained with the homogeneous wave equation and the extended wave equation for inhomogeneous media are compared to each other. It is shown that the characteristics of the fluctuations passing the combustion zone cannot be described properly with the usual simplified approach, even if the combustion zone is modelled by a jump condition of the state variables. To better illustrate the nature of the problem and the source of the errors, the originally analysed complex combustor geometry is reduced to the generic case of a cylindrical tube with a heat release zone. The results of the simulations are compared for different parameters of the heat release model, leading to a stability map of the system. Additionally, the amplitudes of the fluctuations are analysed with the Hilbert-Transformation and growth rates are calculated. The results obtained with both formulations of the wave equation and identical physical models show similar trends but also substantial deviations, which are crucial for the stability analysis of combustion systems. For the further analysis of the observed deviations the extended form of the wave equation is rearranged such that the additional term from the density gradient appears on the r.h.s. as an additional source term. After this step the influence of this term and its interaction with the heat release term is analysed and it is shown that the application of the extended form of the wave equation is required for the appropriate simulation of the thermo-acoustic processes within complex combustion systems.

Keywords: Thermo-Acoustic, Wave Equation, Density Gradients

[*]Corresponding author: wanke@td.mw.tum.de

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

An Analysis of Heavy Fuel Oil Combustion in Utility Boiler

H. Hasini*, N. Maruf, N. H. Shuaib and K. Munisamy

Department Of Mechanical Engineering, College Of Engineering,
Universiti Tenaga Nasional,
43009 Kajang, Selangor, Malaysia

ABSTRACT
The use of fossil fuel for energy conversion in the world today still contribute to the majority of fuel conversion methods. Among of the largest consumer of fossil fuel is power station boiler furnace. Due to the limited sources of these type of fuels, it is predicted that the price of these fuels will increase with time. This scenario has been demonstrated in the current increase in fossil fuel price in the world market. The trend is predicted to increase further with time due to the increase in energy demand. Therefore, there is an urgent need to improve combustion efficiency and at the same time to reduce fuel consumption. In addition, to face the increasingly more restrictive emission regulations, improved combustion strategies and burner designs are also required. The full-scale boiler combustion involves complex reactive flow and it is often hard to obtain a detail measurement in order to evaluate the boiler performance. This paper attempt to investigate the flow and combustion characteristics in an oil-fired, full-scale furnace at design condition for different loading conditions. The modeling was done using a finite volume-based commercial CFD-code, FLUENT. The simulations are executed in three stages with increasing complexity namely mixing, adiabatic combustion and combustion with the effect of heat transfer to the furnace wall. The results of the simulations show that the flow inside the furnace is highly swirling with high intensity of mixing of fuel droplet and air. In general, the prediction of temperature distribution at furnace re-heater elevation shows a promising agreement with actual data obtained from the boiler under operation. On top of that, the predicted flow pattern and temperature distribution inside the furnace show reasonably good qualitative agreement with practical observation. Comparison with well-established data also revealed a reasonable accuracy in terms of flow characteristics and temperature distribution inside the full scale furnace.

*Corresponding author: hasril@uniten.edu.my

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Direct Numerical Simulation of Scalar Correlation-Moment Transport in Isothermal Turbulent Reacting Flows

F. Wang, C.X. Xu, L.X. Zhou*, J. Zhang

Department of Engineering Mechanics,
Tsinghua University
Beijing 100084, China

ABSTRACT
Although the direct numerical simulation (DNS) of reacting flows and combustion was studied by many authors, but only a few studies are used to validate the RANS modeling, such as the CMC and flame-let models. In this paper, the direct numerical simulation of isothermal turbulent reacting channel flows and scalar correlation-moment transport in with two reacting species was carried out using a spectral method. The Galerkin-Tau method is used as the spectral expansion method, the Fourier transformation is used in x and z directions, and the Chebyshev transformation is used in the y direction. The structure of reacting scalar fluctuation and the budget of some important terms in the transport equation of scalar correlation moments are studied and the closure models in the correlation moment equation of RANS modeling are validated. The obtained statistically averaged and RMS values of concentration for a single species in non-reacting flows are in good agreement with those obtained using a finite-difference method reported in references. The DNS instantaneous results give detailed structures of reacting scalar fluctuation, showing the strip structures of concentration fluctuation in the near-wall region. The DNS statistical results give the budget of the exact concentration correlation-moment equation, showing that the production term and dissipation term are most important and the effect of diffusion and reaction terms is rather small.. The DNS statistical data are then used to validate the closure models in the correlation moment equation of RANS modeling. It is found that the dissipation term is well simulated, while the simulated values of diffusion and production terms are in agreement with the DNS data in most flow regions, except in the near-wall region.

Keywords: Direct Numerical Simulation, Spectral Method, Scalar Correlation Moment, Isothermal Reacting Flows

*Corresponding author: zhoulx@mail.tsinghua.edu.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Large-Eddy Simulation of Propane-Air Swirling Un-Premixed Combustion Using Different Combustion Models

W.L. Wang, L.X. Zhou*, R.X. Li

Department of Engineering Mechanics,
Tsinghua University
Beijing 100084, China

ABSTRACT

The propane-air swirling un-premixed turbulent combustion with an annular fuel inlet is studied by large-eddy simulation using a Smagorinsky-Lilly sub-grid scale (SGS) turbulence model and two different combustion models: EBU model and second-order moment (SOM) SGS model. The basic governing equations for LES are filtered three-dimensional continuity, momentum, energy and species equations. The sub-grid scale stress, heat flux and mass flux are closed by a Smagorinsky-Lilly SGS turbulence model, the filtered reaction rate is closed by a eddy-break-up (EBU) model, or alternatively the sub-grid scale reaction rate is closed by a second-order moment (SOM) model, expressing the effect of small-scale turbulence on the reaction rate. The grid nodes are 450,000 hexagon; a full implicit second-order scheme for the time changing-rate term and a QUICK scheme for the convection and diffusion terms are adopted. The PISO algorithm is used for pressure-velocity corrections. The statistical results of LES predicted temperature, species concentration, time-averaged velocity components and RMS values of fluctuation velocity components are compared with those obtained by experiments reported in references. The comparison shows that both two combustion models give good or fairly good agreement with the experimental data, whereas in major places the LES-SOM results are somewhat better than the LES-EBU results. The LES instantaneous results give the large eddy structures and the flame structures, showing that the annular fuel inlet makes the turbulence and temperature more uniform, intensifying combustion. No distinct flame surface is observed.

Keywords: Large-Eddy Simulation, Swirling Un-Premixed Combustion,
Second-Order Moment Model

*Corresponding author: zhoulx@mail.tsinghua.edu.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

The Design of a Multi-Ring Gas Burner for Optimal Energy Utilization and Nitride Oxide Emission

J. T. Yang[1*], Y. C. Luo[1], C. C. Li[1], K. K. Wu[2], and J. L. Cheng [21]

[1] Department of Power Mechanical Engineering,
National Tsing Hua University
[2]The Energy and Resources laboratories,
Industrial Technology Research Institute
Taiwan, R.O.C.

ABSTRACT
The effects of burner gap (S/d) and equivalence ratio (φ) on combustion performance in various multi-ring burners have been numerically investigated. The variations of burner gap and equivalence ratio alter the mixing pattern between the fuel and the oxidizer and the preheating effect. It resulted in different flame reaction rate, burning velocity, heat release rate, flame length and production of emission. Therefore, the global flame structure is also different. The optimal operation condition is deduced and at which condition the emission of nitride oxide is significantly reduced. When the S/d decreases, the flame-interaction is enhanced and both the mixing degree between the fuel and the oxidizer and the preheated temperature are raised. Consequently, the mean-temperature increases and the range of high temperature zone becomes bigger as S/d is decreased. Since the residence time of the burnt gas in the high-temperature zone becomes longer, the production of NOx increases. When S/d =1.33 and φ =1.35, the mean-temperature is 1707K and the production of NOx is 92 ppm. As S/d is shortened to be 1.0 at the same equivalence ratio, the mean-temperature is 1821K and the production of NOx is 223 ppm. The mean-temperature increases about 7 %, but the production of NOx increases 140%. There are similar results when the equivalence ratio is varied.

Keywords: Burner, Equivalence Ratio, NOx, Flame-Interaction

[*]Corresponding author: jtyang@pme.nthu.edu.tw

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

The Tesla Turbine Revisited

Heraldo da Silva Couto[1], João Batista Furlan Duarte[1], Demétrio Bastos-Netto[2*]

[1] Department of Mechanical Engineering,
Universidade de Fortaleza, UNIFOR - University of Fortaleza,
Fortaleza, Ceará, 60811-905, Brazil

[2] Combustion and Propulsion Laboratory,
Instituto Nacional de Pesquisas Espaciais (INPE),
INPE – National Institute of Space Research
Cachoeira Paulista, São Paulo, 12630-000, Brazil

ABSTRACT
This work reviews the physical principles behind the Tesla bladeless turbine, an invention of the brilliant Croatian engineer Nikola Tesla. Following a discussion on the relative motion of rotating surfaces, it sets up the transport equations describing the flow between parallel rotating disks, estimating the boundary layer thickness under laminar and turbulent regimes, leading to expressions yielding the width between consecutive disks. Once the working fluid is defined and its entrance conditions are established, then, if the output power is chosen, this work shows how to calculate the total number of disks required to attain the desired performance. Finally, the device behavior acting as an air compressor or water pump is also described. These authors are not aware of a comprehensive discussion of the fluid mechanics involved in the design of those devices having been ever done. Besides the usual applications of rotating machinery, Tesla machines are well fitted when compact unities are required for electric power generation in the cases of isolated areas. It should be noticed that, as a unique source of rotating motion, they run under a wide spectrum of fuels and fluids in general, being useful, for example, as high speed drilling machines, among other applications.

Keywords: Tesla Turbine, Boundary Layer Turbine, Rotating Machinery

[*]Corresponding author: demetrio@lcp.inpe.br

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

A Planar Droplet Sizing Investigation of a Non-Reactive Spray Impact onto an Isothermal Wall

Venelin A. Stamatov, Lilia I. Stamatova, Damon R. Honnery

Laboratory for Turbulence Research in Aerospace & Combustion,
Department of Mechanical Engineering, Monash University
Clayton, 3800, VIC, Australia

ABSTRACT
The investigation of spray impact onto walls is of importance to many industrial processes that utilise sprays, e.g. sprays cooling systems in humidifiers and dryers, spray coating, and Internal Combustion (IC) engines. In IC engines, liquid fuel is atomised to produce a cloud of droplets that subsequently vaporise and burn. However, the fixed geometry of the combustion chamber and spray nozzle makes these engines inflexible. Any changes of the parameters of the fuel (density, viscosity and surface tension) may lead to changes of the dynamic parameters of the spray (penetration and spatial distribution of droplet size), causing spray impingement onto the walls of the chamber, a secondary droplet atomisation and a liquid film formation. This especially is the case, when attempts are made to use alternative fuels (bio-oil and biodiesel) in standard diesel engines. Planar Droplet Sizing (PDS) technique was used to study the dynamic interaction between an isothermal, vertical water spray and a steel wall situated downstream, perpendicularly to the spray axis. PDS technique makes use of the fluorescence light emitted from the dye (in this case Kiton Red) added to the water and the scattered light from droplets. The principle of the PDS technique relies on the assumption that the fluorescence intensity emitted by the fluorescent dye is proportional to the volume of the droplet, and the scattered light intensity is proportional to the droplet surface area. As a consequence, the ratio of the two intensities on an illuminated plane of a spray is proportional to the Sauter Mean Diameter of the droplets. A statistical analysis based on the results from the current work shows that at isothermal conditions no secondary atomisation of the droplets occurs because of the impact, independently of the spray parameters.

Keywords: Spray, Marker Nephelometry, PLIF, PDS, PIV

*Corresponding author: venelin.stamatov@eng.monash.edu.au

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Fixed (Slow Moving) Bed Updraft Gasification of Wood Pellets

Alejandro Grimm and Rolando Zanzi*

Dept. of Chemical Engineering and Technology / Chemical Reaction Engineering,
Royal Institute of Technology (KTH),
S-100 44 Stockholm, Sweden

ABSTRACT

A laboratory-scale countercurrent fixed-bed gasifier has been designed and constructed to produce data for process modelling and to compare the gasification characteristics of several biomasses. Densified woody biomass, birch, in form of pellets with a diameter of 8 mm and a length between 5 and 15 mm has been used as a raw material for batch autothermal gasification using air as an oxidation agent. The main objectives were to study the effect of the treatment conditions on the distribution of the products and the composition of product gas to establish the suitability of the gasifier to produce combustible gas with sufficiently high calorific value.

The influence of the air flow rates on the composition of the producer gas has been studied. The amount of the biomass used in the experiments was varied between 1 and 4 kg and the flow rate of the oxidation agent, air, was varied from 1,1 to 2,6 m^3/h. Increased airflow rates favoured higher temperatures, however, excessively high airflow rates resulted in fast consumption of the biomass and it also favoured combustion over gasification and thus formation of lower amounts of combustible products. High airflow rates caused also higher yields of liquid products, due to the shorter residence time of the tar-rich gas in the gasifier and thus unfavourable conditions for tar cracking.

The higher the flow rate of air the shorter the time required to rich high temperatures and maximum concentrations of the gaseous products. High rates of gas flow favour formation of high concentrations of gaseous products and large amounts of tar. Carbon dioxide and carbon monoxide dominate among the gaseous products. The concentrations of hydrogen, methane and particularly C_2-hydrocarbons are much lower.

*Corresponding author: rolando@ket.kth.se

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Hydrogen and Illuppai Oil as Dual Fuel in a DI Diesel Engine

Sankaranarayanan G.[1] , Jeyachandran K[2]

[1] Dept. of Mech. Engg, Hindustan College of Engg,
Padur, India

[2] Anna University,
Chennai-25, India

ABSTRACT
Everyday the population of the automobiles is increasing resulting more emission and scarcity for fossil fuel. Due to severe crude oil crisis, the use of alternate fuel for diesel engines has received renewed attention. The interdependence, uncertainty of petroleum based fuel availability and galloping crude price has created a need for investigating the possible use of alternate fuel. In recent years, the emphasis to reduce pollutant emissions from petroleum based engines has motivated the researchers for the development and testing of several alternate fuels. In India there are nearly 200 types of oil seeds are available. Vegetable oils can be directly used in compression ignition engines without any modification. The problems of using vegetable oil are high viscosity and gum deposits. The primary problem associated with using pure vegetable oil as a fuel in a compression ignition engine is incomplete combustion due to low volatility. The high viscosity of the vegetable oils is largely responsible for this problem. The Illuppai (Madhuca Indica) oil is used an alternative fuel in this study. This study investigates the performance and emissions on using Hydrogen enriched air inducted into the engine, and injected with Illuppai oil. The experiment was conducted in a single cylinder water cooled di diesel engine. The engine combustion was recorded using Kistler DDAS, emission was monitored with MRU delta emission analyzer and smoke emission was measured with Bosch smoke meter.

*Corresponding author: gs2000narayanan@yahoo.com

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Comparative Analysis of Diesel, Bio-Diesel and Straight Vegetable Oil (SVO) as Fuel in DI Diesel Engine

Mukund V. Subramaniam, S. Sivaprakasam*, C.G. Saravanan

Department of Mechanical Engineering
Annamalai University
Annamalai Nagar - 608002,
Tamil Nadu, India

ABSTRACT
The rapid depletion of non-renewable energy sources such as fossil fuels such as petroleum derivatives due to the ever increasing demand across the globe and also the dangerously increasing pollution levels in the form of emissions has resulted in the need to explore the use of renewable sources of energy as a substitute for the non-renewable ones. Research in this direction with edible oils has yielded encouraging results, but due to higher domestic consumption, the applications otherwise becomes limited. Generally, non-edible oils are been considered as an alternative fuel to diesel for diesel engines. Biodiesel, a biofuel directly substitutable for petroleum-based diesel, can be derived using simple technology from locally grown oil crops in rural regions in developing countries. In this investigation, Straight Vegetable Madhuca Indica Oil, Madhuca Indica methyl ester or Biodiesel and Sole Diesel was used as fuel in the DI diesel engine to carry out performance, emission and combustion tests. Straight Vegetable Oil (SVO) was heated to 160 °C and then cooled back to room temperature. Only then, was SVO used as Sole Fuel in the diesel engine. Biodiesel used in this project was B20, which consists of 20 % Madhuca Indica methyl ester and 80 % diesel. As the results were compared, biodiesel when used as fuel displayed low fuel consumption than SVO, but higher than Diesel. The values for specific fuel consumption were more or less similar for all the three fuels. Diesel and SVO, both indicated similar brake thermal efficiency. In the emission part, Biodiesel was found to emit the least in both smoke as well as particulate matter. However, for NOx the trends were reversed with Biodiesel emitting higher amounts followed by diesel and SVO respectively.

Keywords: Madhuca Indica Oil, Madhuca Indica Methyl Ester, Transesterification, Biodiesel

*Corresponding author: rgssiva2002@yahoo.co.in

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Energy-Saving Technologies Based on Super-Adiabatic Combustion

Polianczyk E.V. [*], Glazov S.V., Manelis G.B.

Institute of Problems of Chemical Physics RAS
Acad. Semenov av. 1, Chernogolovka,
Moscow region,142432,
Russian Federation

ABSTRACT
Modern level of the combustion science provides a basis for development of a number of novel industrial processes using substandard and renewable fuels and more efficient use of conventional ones. The phenomenon of superadiabatic filtrational combustion allows one to perform a chemical conversion with but slight net heat effect at a controllably high temperature. This feature is due to in-process heat recovery achieved without additional heat exchangers. Gasification of substandard fuels (incl. various combustible wastes) by means of superadiabatic combustion additionally to high energy efficiency brings environmental bonus as filtration of the gaseous products through fresh fuel suppresses entrainment of dust particles and secures conditions favorable for neutralization of acidic pollutants. Supeadiabatic combustion provides an option for energy-saving conversion of combustible gases to hydrogen and synthesis gas without use of a catalyst and for highly efficient combustion of lean gases. A number of technologies based on the phenomenon has been developed in the Institute of Problems of Chemical Physics RAS.

[*]Corresponding author: polian@icp.ac.ru

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Performance and Emission Tests on DI Diesel Engine Using SVO of Madhuca Indica at Different Temperature

Mukund V. Subramaniam, L. Mubarak Ali,
S. Sivaprakasam*, C.G. Saravanan

Department of Mechanical Engineering,
Annamalai University
Annamalai Nagar - 608002,
Tamil Nadu, India

ABSTRACT
The petroleum situation across the globe is facing severe crisis due to rapid depletion of fossil fuels. Combined with the degradation of environment due to pollution, there is a resurgence of interest in finding an alternative fuel. Thermodynamic tests based on engine performance evaluation have established the feasibility of using a variety of alternative fuels such as hydrogen, CNG, alcohol, biogas, producer gas, and a host of vegetable oils. The process of utilizing vegetable oil in the Internal Combustion engines for transport as well as other application, is gaining momentum. In this paper, non-edible oil, Madhuca Indica, was used to run the engine and carry out performance, emission and combustion tests. Madhuca Indica was heated at temperatures such as 50 ºC, 90 ºC, 120 ºC, 140 ºC, and 160 ºC. Then tests were carried out at each of these temperatures respectively. From the results obtained it was found that, when Straight Vegetable Oil was heated at 160 ºC, optimal results were obtained for all the tests. A reduction in Nitrogen Oxide formation was observed especially at higher loads when compared to that of diesel. The density of smoke was also found to be lesser than that of diesel. Amount of fuel consumed was least for Straight Vegetable Oil heated at 160 ºC. In the combustion tests, the rate of heat release and peak pressure was found to be maximum, compared to diesel.

Keywords: Madhuca Indica, Straight Vegetable Oil

*Corresponding author: rgssiva2002@yahoo.co.in

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Combustion Characteristics of Compression Ignition Engine Fuelled with Diesel Ethanol Emulsion Blends Under Various Injection Angles

M.P. Ashok, S. Sivaprakasam and C.G. Saravanan*

Department of Mechanical Engineering,
Annamalai University,
Annamalai Nagar 608002
Tamil-Nadu, India

ABSTRACT

Development is going on in the use of diesel engines in the personal automobiles. This is mainly because, compared to petrol engines, diesel engines are more efficient and cost economical. However, the vibration from the engine and the unpleasant emission level in the exhaust are the main draw backs.In this work to considerably reduce the exhaust emission in the diesel engine by using an emulsified fuel. The objective of the present work is to carry out the performance and emission characteristics of a single cylinder direct injection diesel engine using Ethanol-Diesel emulsion. A single cylinder, water cooled, four stroke diesel engine was used for this study. Experiments were conducted with emulsions viz (50%diesel + 50 ethanol), (60% diesel + 40% ethanol), (70% diesel + 30 % ethanol) as fuel. An AVL smoke meter was used to measure the smoke density in HSU. The NO_X emission was measured using the exhaust gas analyzer. High volume sampler was employed to measure the particulate matter in the exhaust. The combustion characteristics were studied using AVL combustion analyzer. From the experimental investigation the smoke, particulate matter and Oxides of nitrogen emissions are reduced marginally. The combustion characteristics under various injection angles fuelled with (50%diesel + 50 ethanol) were investigated. The 50% diesel + 50% ethanol blends showed better results than other percentages. The results indicated that ignition delay, rate of heat release, and peak pressure.

*Corresponding author: rsdk66@yahoo.com

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Hydrogen and Vegetable Oil as Dual Fuel in a DI Diesel Engine

Sankaranarayanan G.[1*], Pugahzvadivu M.[2], Jeyachandran K.[3]

[1] Dept. of Mech. Engg, Hindustan College of Engg,
Padur, India

[2]Pondichery Engg. College,
Pondichery, India

[3] Sri Ramanujar Engg. College,
Vandalur, India

ABSTRACT
Due to severe crude oil crisis, the use of alternate fuel for diesel engines has received renewed attention. The interdependence, uncertainty of petroleum based fuel availability and galloping crude price has created a need for investigating the possible use of alternate fuel. In recent years, the emphasis to reduce pollutant eIlluppaissions from petroleum based engines has motivated for the development and testing of several alternate fuels. In India there are nearly 200 types of oil seeds are available. Vegetable oils can be directly used in compression ignition engines without any modification. The primary problem associated with using pure vegetable oil as a fuel in a compression ignition engine is incomplete combustion due to low volatility. The high viscosity of the vegetable oils is largely responsible for this problem. The Illuppai (Mahua) oil is used an alternative fuel in this study. This study investigates the performance and eIlluppaissions on using Hydrogen enriched air inducted into the engine, and injected with ILLUPPAI oil. The experiment was conducted in a single cylinder water cooled di diesel engine. The engine combustion was recorded using Kistler DDAS, eIlluppaission was monitored with MRU delta eIlluppaission analyzer and smoke eIlluppaission was measured with Bosch smoke meter.

*Corresponding author: gs2000narayanan@yahoo.com

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

An Investigative Analysis of Bio-Diesel in DI Diesel Engine Using Different Blends

Mukund V. Subramaniam, V. Mugesh Raja,
S. Sivaprakasam*, C.G. Saravanan

Department of Mechanical Engineering,
Annamalai University
Annamalai Nagar - 608002,
Tamil Nadu, India

ABSTRACT
Biodiesel, a biofuel directly substitutable for petroleum-based diesel, can be derived using simple technology from locally grown oil crops in rural regions in developing countries. But, due to the high viscosity of raw vegetable oils, direct usage in diesel engines is not feasible. Therefore, in this investigation a process known as Transesterification is carried out before being used directly in the engine. It is an important process for the preparation of biodiesel in which fats and oils are converted into methyl esters in the presence of a catalyst. Firstly, in this investigation Madhuca Indica Oil was transesterified to obtain Madhuca Indica methyl ester using KOH as catalyst. Then, tests such as performance, emission and combustion were carried out using different blends of Madhuca Indica methyl ester and Diesel in ratios of 20%, 40%, 60%, 80% and 100% (by volume) in a twin-cylinder, four stroke, direct injection Diesel Engine. From the different blends tested, the 20% blended ratio i.e. 200 ml Madhuca Indica methyl ester and 800 ml Diesel per liter indicated higher performance and lower emission characteristics. This ratio is commonly known as B20. In the combustion tests, the B20 blend showed maximum heat release and peak pressure, than that of diesel.

Keywords: Madhuca Indica Oil, Madhuca Indica Methyl Ester, transesterification, biodiesel

*Corresponding author: rgssiva2002@yahoo.co.in

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Potentialities of the Biochar Generated from Raw and Acid Pre-Treated Sugarcane Agricultural Wastes

P. R. Bonelli[(1)], M.E. Ramos[(1)], E. L. Buonomo[(1)], A. L. Cukierman[(1) (2)]*

[(1)]Programa de Investigación y Desarrollo de Fuentes Alternativas de Materias Primas y Energía (PINMATE) - Departamento de Industrias - Facultad de Ciencias Exactas y Naturales.
Universidad de Buenos Aires. Intendente Güiraldes 2620.
Ciudad Universitaria. (C1428BGA)
Buenos Aires, Argentina

[(2)]Depto. de Tecnología Farmacéutica. Facultad de Farmacia y Bioquímica.
Universidad de Buenos Aires. Junín 956. (C1113AAD)
Buenos Aires, Argentina

ABSTRACT
Copious amounts of agricultural residues from sugarcane, mostly composed of leaves and tops generated when the plant's stems are cleaned in the conditioning-stage for further industrial processing towards sugar, constitute an attractive biomass resource. Though thermochemical conversion of sugarcane bagasse into useful products has received great attention, effective utilization of sugarcane agricultural residues as biomass feedstock has been scarcely explored. Properties of the biochar, namely the enriched carbon solid product arising from biomass pyrolysis, are highly dependent on the feedstock and process conditions used. In this context, the present work aims at characterizing the biochar produced by slow pyrolysis of the raw agricultural residues from sugarcane at two different temperatures (600 ºC and 800 ºC), to examine potentialities for specific end-uses. Yield, contents of volatiles, ash and fixed carbon, elemental composition, high heating value (HHV), as well as surface properties judged from N_2 (77 K) adsorption isotherms, are determined. Likewise, since pyrolysis of some lignocellulosic biomasses pre-treated with phosphoric acid solutions has demonstrated to yield solid products with well-developed porous structures as those of activated carbon, features of the biochar arising from pyrolysis of the acid-pretreated agricultural wastes are also investigated. According to international standards, the biochar derived from the raw wastes at the higher temperature has potential for briquettes production for domestic use. BET area of this biochar (135 m^2/g) also indicates that it is reasonably suited as low-cost rough adsorbent and/or soil amender. In turn, pyrolysis of the acid pre-treated wastes leads to enhance markedly the yield and porosity development of the resulting biochar (BET area ≈ 740 m^2/g). It is comparable to some commercial activated carbons. Substantial changes induced by the pre-treatment seem to be due to the catalytic action of the acid on the pyrolytic behavior of the residues, promoting degradation at lower temperatures compared to pyrolysis of the raw ones.

Keywords: Sugarcane Agricultural Wastes, Biochar Properties, Pyrolysis, Biofuel, Activated Carbon

*Corresponding author: analea@di.fcen.uba.ar, acukierm@yahoo.com.ar

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Thermal Degradation Characteristics of Post-Consumer PET Mixed with Wood Wastes

M.R. Kim[1], J.D. González[1], E.L. Buonomo[1], P.R. Bonelli[1], A.L. Cukierman*[1,2]

[1]Programa de Investigación y Desarrollo de Fuentes Alternativas de Materias Primas y Energía (PINMATE). Depto. de Industrias. Facultad de Ciencias Exactas y Naturales. Universidad de Buenos Aires. Intendente Güiraldes 2620. Ciudad Universitaria. (C1428BGA) Buenos Aires, Argentina

[2]Depto. de Tecnología Farmacéutica. Facultad de Farmacia y Bioquímica. Universidad de Buenos Aires. Junín 956. (C1113AAD) Buenos Aires, Argentina

ABSTRACT
Poly(ethylene terephtalate) (PET) is currently one of the major post-consumer plastic wastes. The disposal of this waste represents a serious challenge for industrial countries, due to its low bio- and photo-degradability. Likewise, accumulation and/or open field burning of copious wood biomass from forestry and industrial processing constitute another threat to the environment. The implementation of new routes for recycling thermoplastics has become a goal in the field of environmental protection with the aim of making plastics manufacturing a sustainable technology. Co-pyrolysis could provide an alternative, economically viable route for co-processing PET and wood wastes due to the favourable, environmental nature of lignocellulosic wastes and the potential uses of the resulting products: energy from pyrolysis gases, recovery of valuable chemicals, and enriched-carbon solid residue (char). Within this context, in the present work, thermal degradation of mixtures composed by poplar sawdust and PET bottle residues in equal proportions is comparatively investigated with respect to their individual components. Experiments in a tubular reactor under inert atmosphere for temperatures comprised between 400°C and 600ºC are conducted to examine yield and products characteristics. The presence of PET wastes in the mixture is found to reduce formation of the residual solid product (char), consequently favoring generation of gaseous and/or condensable volatile products. The trend is more pronounced as pyrolysis temperature increases, owing to the growing release of volatile matter, as evidenced from chemical characterization of the resulting chars. Textural characterization of the latter also points to a pronounced development of porosity for the char arising from the mixture at 500ºC, suggesting its potential use as an adsorbent. On the other hand, kinetic characterization of the thermal degradation of PET waste, poplar sawdust, and a mixture of both residues under inert atmosphere is carried out from non-isothermal thermogravimetric measurements over the range of temperatures from 25 to 900°C and modelling of the experimental data.

Keywords: Co-Pyrolysis, Waste PET, Poplar Sawdust

*Corresponding author: analea@di.fcen.uba.ar, acukierm@yahoo.com.ar

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Co-Processing of Coal and Biomass for Energy Generation: Characterization of Thermal Events and Kinetics of Pyrolysis

P. Bonelli[(1)], D.A. Zilli[(1)], J.D. González[(1)], A.L. Cukierman[(1) (2)]*

[(1)]Programa de Investigación y Desarrollo de Fuentes Alternativas de Materias Primas y Energía (PINMATE) Depto de Industrias. Facultad de Ciencias Exactas y Naturales. Universidad de Buenos Aires. Intendente Güiraldes 2620.
Ciudad Universitaria. (C1428BGA)
Buenos Aires, Argentina

[(2)]Depto. de Tecnología Farmacéutica. Facultad de Farmacia y Bioquímica. Universidad de Buenos Aires. Junín 956. (C1113AAD)
Buenos Aires, Argentina

ABSTRACT
Co-utilisation of coal and biomass for energy generation has received growing attention in recent years because it is perceived as an alternative, strategic means for development of cost-effective, environmentally friendly technologies. High impact of co-processing lies on the necessity of diminishing harmful gaseous emissions arising from coal, fossil fuels substitution, and reduction in investment costs required for construction of new plants exclusively based on biomass resources. Another major reason in several regions worldwide is the difficulty associated with disposal of wastes in landfills because of the volume and environmental constraints. Particularly, information on kinetics of the pyrolysis of coal-biomass blends is relevant to the efficient design, operation and modeling of full-scale conversion units for co-processing since pyrolysis constitutes the first-stage of both combustion and gasification. In this direction, the purpose of this study is to examine systematically thermal events and kinetics of pyrolysis of blends composed of equal proportions of a subbituminous coal from an Argentinean minefield and sugarcane agricultural residues, used as a representative biomassic resource, accounting for the individual pyrolytic behavior and main physicochemical properties of both fuels. Kinetic characterization is performed by non-isothermal thermogravimetric analysis from ambient temperature up to 900 ºC under flowing nitrogen, and data modeling. Results show that coal pyrolysis begins at a higher temperature (~ 275 °C) and proceeds more gradually than the biomass, whereas the blend exhibits an intermediate pyrolytic behavior between those of the constituent fuels. Pyrolysis rates for the biomass and the blend attain a maximum at around 300 °C, even though a lower value characterized the latter due to coal effect. The higher content of volatiles of the biomass and differences in structure between coal and biomass explain the pyrolytic behavior found for the individual fuels and the coal-biomass blend, that are well reflected in the estimated kinetic parameters.

Keywords: Sugarcane Agricultural Residues, Pyrolysis, Co-Pyrolysis Kinetics, Sugarcane Residues – Argentinean Coal Blend

*Corresponding author: analea@di.fcen.uba.ar, acukierm@yahoo.com.ar

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Filtrational Combustion of Humid Fuel

V. M. Kislov, E. A. Salgansky*, S. V. Glazov, M. V. Salganskaya, E. V. Polianczyk, A. F. Zholudev, G. B. Manelis

Institute of Problems of Chemical Physics RAS,
Acad. Semenov av. 1, Chernogolovka,
Moscow region, 142432,
Russian Federation

ABSTRACT
This study is aimed at development of technologies for processing of low-calorie and wet fuels by means of gasification in the super-adiabatic filtration combustion. Air gasification of a wet fuel/solid inert material mixture was experimentally studied on a 46-mm-diameter laboratory installation. The fuels used were a commercial activated birch charcoal and pine wood. The fuel content in the mixture was varied within 5 – 100%, the fuel humidity within 9 – 70%. The basic characteristics of the coal gasification (temperature, composition of gaseous products, mass flowrate, etc.) were not sensitive to humidity. An increase in humidity resulted only in a small drop in the combustion temperature. Throughout the studied parametric domain, a steady propagation of filtration combustion was observed. For gasification of wood, the humidity affected the process for lower content of inert in the mixture as evaporation of water changed conditions of pyrolysis occurring ahead of the combustion front.

Keywords: Filtrational Combustion, Humid Fuel, Super-adiabatic.

*Corresponding author: sea@icp.ac.ru

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Application of Pinch Technology in Air Pollution Modeling

Y. Rohani [1], M.H. Panjehshahi [2], B. Dabir [1]

[1] Department of Chemical Engineering,
Amir-Kabir University of Technology,
Iran

[2] Department of Chemical Engineering,
Faculty of Engineering
University of Tehran,
Iran

ABSTRACT
In this paper using thermal pinch and mass pinch concepts, a new application of pinch technology is introduced in air pollution analysis. Considering pinch analysis concepts, employing this method contains two steps: 1. Target stage; 2. Design stage. In this research target setting, optimizing the target and determining the pinch point for air pollution analysis are presented. The calculations are done for a residential area of 10*10 square kilometers.

Keywords: Pinch Technology, Air Pollution, Air Pinch

*Corresponding author: drbdabir@cic.aut.ac.ir

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Analysis of Reductive Abilities of Hydrazine Compounds Under Moderate to High Temperatures and Their Reduction Effect on NO_x in Incineration Flue Gases

Dezhen Chen[1*], Zhengyu Wang[1], Zuoming Zhang[1], and Yu Lin[2]

[1]Thermal and Environmental Engineering Institute,
Tongji University,
Shanghai 200092, China

[2]Baosteel Technique Center, Shanghai 201900, China

ABSTRACT

For municipal solid waste incinerator ammonia is often sprayed into the furnace in the temperature of 850~1000 ℃ for NOx emission control and for dioxins formation prevention. The ammonia in surplus will escape from the furnace which is a big environmental concern; on the other hand ammonia is not effective for dioxins formation prevention and activated carbon is often needed for further interception which resulted in extra hazardous waste. In this paper, hydrazine compounds were checked for their effect on non-catalytic NOx control in incineration flue gas within temperature range of 400-800 ℃. Firstly the possible reaction products between hydrazine and NOx within temperature range of 400-800 ℃ were calculated by principles of chemical thermodynamics and then experiments were performed to verify the reductive effects of hydrazine on NOx. The calculation results indicate that hydrazine compounds have a strong trend to reduce NOx within temperature range of 400~800 ℃ where ammonia doesn't work without help of catalyst. The experimental results showed that even under oxygen partial pressure high up to 13% hydrazine compounds did have reductive effects on NOx under 400~800 ℃ while ammonia promoting the formation of NOx under the same conditions. The hydrazine compounds are not only useful for NOx control for incineration flue gas but also are expected to prohibit dioxin formation due to their strong reductive characteristics and being nitrogen-rich chemicals which are theoretically valid for dioxin control, this part of work will be discussed somewhere else.

Keywords: Hydrazine Compounds; Incineration Flue Gas; NOx; Dioxins

[*]Corresponding author: chendezhen@mail.tongji.edu.cn; chd@er.dtu.dk

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Removal of Fluoride from Phosphoric Acid Production Plants

Fariborz Rashidi[*] and Reza Ranjbar

Chemical Engineering Dept.
Amirkabir University of Technology
Tehran-IRAN

ABSTRACT

In this research different ways for treatment of the fluoride-containing wastewaters of a variety of phosphate production units were studied. This study was concentrated on the parameters which affect the separation of fluoride and phosphate ions from the wastewater. The fluoride and phosphate ions are present in form of fluosilicic acid and phosphorous pentoxide, respectively. During the separation process, some calcium fluoride and silica is formed. Some new features of a common production procedure of calcium fluoride and precipitated silica were declared. The first goal was to improve both the removal of fluoride and phosphate ions and the efficiency of production of valuable calcium fluoride and precipitated silica. In order to reach the goals, all the common ways of F^- and P_2O_5 separation were studied and tested in laboratory scale. It was found that the most proper way to do this is the sequential mixing of the wastewater with calcium carbonate and calcium hydroxide. The most influencing factors, namely pH, mesh size of the reactants, concentration of the neutralizing dispersion, mixing intensity, sequence and rate of addition and the duration of the reaction were studied and optimized.

As no clear mechanism has been offered for the reaction and some unclear phenomena were occurring during the reaction, the mechanism of the reaction was studied in a more detailed manner. Having studied the results of a large number of research works on the reaction, we suggest a new mechanism which has the ability to explain many features of this reaction. In this mechanism the occurrence of four serial intermediate reactions was proposed, in which some intermediate compounds are formed. This is the first explanation for this reaction, which can explain the formation of the observed products in the same order of the observations. Using this mechanism we were able to optimize reaction conditions in order to improve the removal process and the efficiency of calcium fluoride and precipitated silica.

[*]Corresponding author: rashidi@aut.ac.ir

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Distribution of Bromine in the Pyrolysis of Printed Circuit Board Wastes

H.Y. Zhao*, K. Peng, M. Li, S.Q. Li, Q. Song, Q. Yao

Key Laboratory for Thermal Science and Power Engineering
of Ministry of Education,
Department of Thermal Engineering,
Tsinghua University,
Beijing, 100084, China

ABSTRACT
Pyrolysis is an effective method to recycle printed circuit board wastes, but 5~15% Br in printed circuit board wastes are difficult to be treated. In this paper, printed circuit board wastes were pyrolyzed at the temperature of 400, 450, 500 and 550℃ in a 1-2kg/h continuous tubular reactor with the internal rotating paddles and the distributions of Br were analyzed by combustion method. Results showed that with increasing temperature the pyrolysis yield of solid residue decreased but the liquid and gas yields increased. The amount of Br in the solid product also decreased while in the gas phase it increased at elevated temperature, indicating that brominated flame retardants in printed circuit board wastes decomposed. Br content in the liquid product was at its lowest at the of 450℃ and after 450℃ it increased, suggesting that there were new brominated compounds in the experiments, and the reason is that the amount of inorganic Br increased in experiments.

Keywords: Printed Circuit Board Wastes (PCBs), Pyrolysis, Bromine, Distribution

*Corresponding author: hy-zhao@tsinghua.edu.cn

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Production of Activated Carbon from Residue of Liquorices by Chemical Activation

T. Kaghazchi*, M. Soleimani, M. Madadi Yeganeh

Department of Chemical Engineering,
AmirKabir University of Technology,
No.424, Hafez Ave., Tehran, Iran

ABSTRACT
Activated carbon, due to its special characteristics as an adsorbent has found various applications in the industries dealing with separation or catalytic processes. Important applications are related to their use in water and industrial wastewater treatment for removal of flavor, color, odor and other undesirable organic impurities. Apart from such interesting properties as very high surface area, different pore-size distributions and different functional groups, which can be modified by changing activation conditions, the availability and abundance and consequently low price of the raw materials, have made activated carbon to appear as an economical product in the industries. Activated carbon can be produced from a large variety of raw materials. Common examples of commercial feed stocks are coal, wood and agricultural wastes such as fruit stones (apricot and cherry stones), hard shell (almond and pecan shell), coconut shell, bagasse, olive waste, etc. In this work, the production of activated carbon from residue of liquorices by chemical activation has been studied. The activation was performed using phosphoric acid under different operating conditions. The effects of parameters such as particle size, impregnation ratio of chemical agent, final activation temperature and heating rate on the physico-chemical properties of activated carbon were investigated. Production tests for the effects of these factors were designed with Taguchi method. Experimental results showed that the selection of impregnation ratio of chemical agent plays a very important role in the properties of activated carbon. The properties of prepared activated carbon at optimum operating conditions such as surface area ($1130 m^2/g$) and iodine number (923 mg I_2/gr C), were compared to those of commercial activated carbons.

Keywords: Activated Carbon, Production, Residue of Liquorices, Characterization

*Corresponding author: kaghazch@aut.ac.ir

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Study of Chromium Sorption from Aqueous Solution on Sawdust

M. Nikazar*, H. Sharifi , Z. Milani

Center of Excellency of Petrochemical Engineering
Department of Chemical Engineering,
Amirkabir University of Technology,
Tehran, Iran

ABSTRACT
The effect of sawdust to adsorb chromium from aqueous solution was studied .The effects of solution pH, initial concentration, temperature, particle size and sawdust concentration were studied in batch experiments. Experimental studies were carried out to determine the effects of inlet pH, temperature, metal concentration, particle size, flow rat e of solution and column height on chromium sorption in the sawdust fixed-bed columns. As the inlet pH was decreased, the column performance improved. The results show that increasing temperature, sawdust quantity and decreasing pH value, initial concentration and particle size due to increase in adsorption and increase in break through point. The Langmuir and Freundlich isotherm theories were determined ; the Freundlich model was found to be the best represent the equilibrium isotherm data.

Keywords: Sawdust, Adsorption, Chromium, Adsorption Isotherm, Agricultural Waste

*Corresponding author: nikazarm@yahoo.com

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Experimental Studies of Bluff Body Stabilized LPG Diffusion Flames

D. Y. Kiran and D. P. Mishra

Combustion Lab
Department of Aerospace Engineering
Indian Institute of Technology, Kanpur
Kanpur-208 016, UP, India

ABSTRACT

Flame stability of a turbulent jet diffusion flame has received renewed attention in recent years due to its practical applications. An experimental study is carried out to investigate the effect of co-axial air velocity, U_a, and lip-thickness, δ of the bluff–body on the flame stability limits and emission levels. The stability limits of a typical diffusion flame can be characterized in terms of two parameters namely flame lift-off height and blow off velocity. It is experimentally observed that lift-off height is not linearly dependent on the fuel exit velocity, U_f, as compared to the simple jet. The flame stability is observed to be improved at higher lip-thickness bluff body due presence of the wake region behind the bluff body. Flame length is found to be dominated by buoyancy and momentum regimes. The transition from buoyancy to momentum is being extended with increase in lip thickness. For momentum dominated jet diffusion flames, L_f/D_f remains almost constant and therefore is independent of the jet Froude number. The blow-off limit is also extended further by 10% as compared to simple and coaxial jet diffusion flames under similar conditions. The emission levels of mainly four species such as NOx, CO, CO_2 and O_2 are measured. The emissions data are reported in terms of mass based emission index, $EINO_x$ (g [NO_x] / kg [fuel]) and EICO for a wide range of flow conditions. It is concluded that the addition of coaxial air in the higher lip-thickness bluff body flames causes a marginal reduction in emission levels relative to lower lip-thickness bluff-body as the intensity of mixing of fuel and coaxial air in the recirculation gets enhanced in the presence of higher lip-thickness bluff body. Besides this, flame stability and emission characteristics, $EINO_x$ scaling was also investigated extensively. Parameters considered for scaling of $EINO_x$ are convective time scales, $\rho_f U_f / D_f$ and flame residence time, $L_f^3 / U_f D_f^2$. From these studies it is concluded that the flame residence time scaling is not satisfactorily scaled whereas convective time scales and $\rho_f U_f / D_f$ are scaled appropriately in all the cases. It is expected that these studies can be helpful in designing efficient diffusion based burners for a wide range of applications.

Keywords: Lift-off, Lip-Thickness, $EINO_x$ Scaling

*Corresponding author: mishra@iitk.ac.in

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Removal of Sulphur Dioxide by Calcium-Based Materials from Different Sources in South Africa

Z.O. Siagi[1], M. Mbarawa[1], A.R. Mohamed[2], K.T. Lee[2], and I. Dahlan[2]

[1]Department of Mechanical Engineering,
Pretoria Campus, Tshwane University of Technology,
Private Bag X680, 0001,
Pretoria, South Africa

[2]School of Chemical Engineering,
Engineering Campus, Universiti Sains Malaysia,
Seri Ampangan, 14300 Nibong Tebal,
Pulau Pinang, Malaysia

ABSTRACT
South Africa is an energy intensive country, with a high reliance on electricity and primary energy resources such as coal and imported oil. Coal presently provides about 75% of South Africa's primary energy needs, and over 90% of electricity in this country is coal-derived. This is likely to remain the scenario until alternatives such as nuclear energy, natural gas, hydro or other renewable energy sources start to play a more significant role. Coal reserves will last several hundred years at current consumption rates, making it South Africa's most abundant indigenous primary energy resource. During coal combustion, the sulphur in the coal is oxidized and released in the form of SO_2. The SO_2 emissions, in the atmosphere, combine with moisture to form an acid, which returns to the ground as acid rain. SO_2 is associated with causing breathing problems and, as acid rain, it leads to acidification of streams and other water masses, damages trees and agricultural crops, and leads to degradation or destruction of buildings and monuments. Airborne SO_2 and its derivatives can also contribute to degradation of visibility due to formation of a haze. Due to these negative health and environmental effects, and considering the importance of coal to the South African energy sector, it is desirable to control the SO_2 emissions from South African power stations. In the present study, the sulphation reactions of two limestone and two dolomite materials from quarries in South Africa were investigated in an isothermal fixed bed reactor under conditions similar to those in bag filters of the spray-drying flue gas desulphurization system. The raw materials used in this study were calcined at 900 ^oC and the produced quicklime slaked. The fixed bed reactor was operated batchwise with a single charge (0.1g of the sorbent material dispersed in 3g of inert silica sand) of particles for obtaining the SO2 breakthrough curves. Experiments were carried out at different temperatures ($60 \leq T \leq 100\ ^oC$) and SO2 feedstock concentration ($1000 \leq C \leq 4000$ ppm SO_2). In addition, the effects of other operating variables (relative humidity, particle size, NO concentration) on the SO_2 breakthrough curves have been examined.

Keywords: Sorbents, Dolomite, Limestone, Flue Gas Desulphurisation

*Corresponding author: MbarawaMM@TUT.ac.za

8th Asia-Pacific International Symposium on Combustion and Energy Utilization,
October 10-12, 2006, Sochi, Russian Federation
ISBN 5-89238-085-8

Flame Interaction and NOx Emission in a Three-Ring Gas Burner

Y.C. Law[1] ,C.C. Li[1], J.T.Yang[1*], K.K.Wu[2], and J.L.Cheng[2]

[1]Department of Power Mechanical Engineering,
National Tsing Hua University
Taiwan, R.O.C.

[2]Industrial Technology Research Institute
Taiwan, R.O.C.

ABSTRACT

In this study, the effects of non-continuous combustion reaction on partial premixed flame structure have been investigated using computational and experimental methods. There are two different kinds of flame structure on the partial premixed flame. One is premixed flame structure and the other is diffusion flame structure. The different reaction rates between the premixed flame and diffusion flame induce the non-continuous transition area of combustion reaction. The range of this area depends on the difference of reaction rate between these two structures, and the heat lost decreases as this area decreased. Therefore, the overall combustion reaction becomes more efficiency. To alter the gap S/d of multi-ring combustor and equivalence ratio obtain the different level of the flame-interaction. This phenomenon will drastically influence overall flame reaction rate. When the S/d value decrease, this interaction changes the molecular diffusion speed thus the mixed effect between fuel and oxidizer will be upgraded. Furthermore, the smaller S/d value has higher preheating effect. The increased temperature of the residual fuel will raise the energy of fuel molecular to pass the threshold of activation energy. Therefore, the diffusion flame combustion reaction rate will be increased. Three equivalence ratios 1.1, 1.35 and 1.5 are used in this work. The quantity of residual fuel increases as equivalence ratio increased, and improves the collision probability between fuel and oxidizer. Consequently, the diffusion flame reaction rate will be increased.

[*]Corresponding author: jtyang@pme.nthu.edu.tw

ISBN 5-89238-085-8

Title	ABSTRACT BOOKLET OF THE EIGHT ASIA-PASIFIC INTERNATIONAL SYMPOSIUM ON COMBUSTION AND ENERGY UTILIZATION (8th APISCEU)
Publisher	Institute of Applied Mechanics, UB of the RAS & Sochi Research Center of the RAS
International Organizing Committee Chairman	Prof. ZHANG, Xiaoqian
International Organizing Committee Honorary Chairman	Prof. HUANG, Zhaoxiang
Technical & Local Committees Co-Chairmans	Acad. LIPANOV, A.M. Prof. AMIRKHANOV, M.M.
Editors	Acad. Alexey M. LIPANOV Dr. Alexander N. LUKIN
In print	September 2006
Pages	75
Edition	First
Made in	Sochi Research Center of the RAS ©

Booklet Art-Design, Equipment & Software is provided by Dr. Alexander N. Lukin

ISBN 5-89238-085-8

8th APISCEU

Online Informations: http://APISCEU.NAROD.RU

8th APISCEU Co-organized by the Following Organizations and Institutions

Institute of Engineering Thermo-Physics, Chinese Academy of Sciences, China
Combustion Institute, USA
Sochi Research Center, Russian Academy of Science, Sochi, Russian Federation
Institute of Applied Mechanics, Ural Branch of the Russian Academy of Sciences, Izhevsk, Russian Federation
Scientific Council on Combustion and Explosion of the Presidium of the Russian Academy of Sciences, Moscow, Russian Federation
Joint-Stock Company "SG Tours", Sochi, Russian Federation

Official Tour-Operator of Symposium: SG Tours Company: URL: http://www.sgtours.ru