ANNUAL REPORT
FOR THE YEAR 2011

OF THE

INTERNATIONAL ENERGY AGENCY
IMPLEMENTING AGREEMENT FOR
ENERGY CONSERVATION AND
EMISSIONS REDUCTION IN COMBUSTION

prepared by the
Executive Committee Secretariat

for
Dennis Siebers, Agreement Operating Agent
Sandia National Laboratories - California

ANNUAL REPORT
FOR THE YEAR 2011

OF THE

INTERNATIONAL ENERGY AGENCY
ENERGY CONSERVATION AND EMISSIONS REDUCTION IN COMBUSTION IMPLEMENTING AGREEMENT

Program of Research

Published by the
Executive Committee Secretariat
for
Dennis Siebers, Operating Agent
Sandia National Laboratories – California

CONTENTS

* * *

EXECUTIVE ABSTRACT

The purpose of the IEA Implementing Agreement on Energy Conservation and Emissions Reduction in Combustion program is to improve fundamental and applied combustion technology which is developed to provide predictive design capabilities for internal combustion engines, furnaces, and gas turbines. This document summarizes the progress made in this agreement year.

Since 1978, IEA cooperative research by program participants has focused on developing experimental and computational tools to aid combustion research and on developing advanced laser-optical diagnostic tools that permit time- and space-resolved measurements of combustion phenomena for achieving this end. The Agreement's Annex structure has been planned to improve the modeling and simulation processes as well as the instrumentation required for the supporting experimental activities. In order to stimulate additional multi nation cpllaborations the Annex structure was revised in the current agreement year to enable a more deliberate focus on such collaborative activities. The opportunity for invididual contributions was retained to satisfy the desires of those members who wished to contribute in that manner.

The Annex structure to be followed going forward is given below.

Annex 1 Individual Contributor Tasks

Area 1 Advanced Piston Engine Technology

Area 2 Advanced Furnace Technology

Area 3 Fundamentals

Area 4 Advanced Gas Turbine Technology

Annex 2 Sprays in Combustion (Collaborative Task)

Annex 3 Homogeneous Charge Compression Ignition (Collaborative Task)

Annex 4 Advanced Hydrogen Fueled Internal Combustion Engines (Collaborative Task)

Annex 5 Alternative Fuels (Collaborative Task)

Annex 6 Nanoparticle Diagnostics (Collaborative Task)

Annex 7 Hydrogen Enriched Lean Premixed Combustion for Ultra-Low Emission Gas Turbine Combustors (Collaborative Task)

Annex 8 Supporting Activities

YEAR 2011 -2012 ACTIVITIES OF THE EXECUTIVE COMMITTEE

The Executive Committee (ExCo) of the International Energy Agency's (IEA) Program of Research, Development and Demonstration on Energy Conservation and Emissions Reduction in Combustion coordinates the cooperative efforts undertaken by participating institutions. The Committee met twice during the business year. The first meeting took place in March at IEA headquarters in Paris. The second took place following the Agreement's Thirty-third Task Leaders Meeting in August in Lund, Sweden.

Actions taken by the Executive Committee this year include:

Task Leaders Meeting: The Thirty-third Leaders Meeting, sponsored by the Executive Committee was held at the Grand Hotel in Lund, Sweden in August. Principal Investigators, Executive Committee members, and invited guests gathered to hear papers presented on the Agreement's research

Executive Committee Meetings: Minutes of the Executive Committee's meetings of March and August have been published and distributed to IEA Headquarters and to ExCo members. The Proceedings of the Thirty-third Task Leaders Meeting were published and distributed to IEA Headquarters and Executive Committee members for distribution to participants. The Agreement's Annual Reports and 30 Year Anniversary Report are available on the public web site.

Agreement Leadership: At its August meeting, the Committee unanimously chose as Chairman, Prof. Choongsik Bae of Korea to direct the Agreement's activities for the forthcoming year. Mr. Gurpreet Singh of the United States was elected vice-chair.

Future Meetings: The Executive Committee scheduled its next meetings for April 2012 at IEA Headquarters, Paris and October 2012 in Korea The October meeting will be held immediately following the 34th Task Leaders meeting and at the same location.

EXECUTIVE COMMITTEE MEMBERSHIP

as of September 30, 2011

BELGIUM	Dr. Philippe Ngendakumana Alternate: Dr. Veronique Dias
CANADA	Dr. Gregory J. Smallwood Alternate: Dr. Kevin Thomson
FINLAND	Prof. Martti Larmi Alternate: Mr. Heikki Kotila
GERMANY	Prof. Frank Behrendt
ITALY	Prof. Felice E. Corcione Alternate: Dr. Gerardo Valentino
JAPAN	Prof. Yasuo Moriyoshi Alternate: Prof. Eiji Tomita
KOREA	Prof. Choongsik Bae Alternate: Prof. Kyoungdong Min
NORWAY	Dr. Marie Bysveen Alternate: Prof. Ivar S. Ertesvag
SWEDEN	Dr. Bernt Gustafsson Alternates: Prof. Marcus Alden, Dr. Sven-Inge Moller and Prof. Bengt Johansson
SWITZERLAND	Dr. Sandra Hermle Alternates: Mr. Stephan Renz and Dr. Peter Jansohn
UNITED KINGDOM	Prof. Douglas Greenhalgh Alternates: Profs. Philip Hutchinson, Hongming Xu, and Alex Taylor
UNITED STATES	Mr. Gurpreet Singh

For the 2011 Agreement Year, the Operating Agent for the Energy Conservation and Emissions Reduction in Combustion Implementing Agreement was Dr. Dennis Siebers, Sandia National Laboratories, Livermore, California, USA.

Dr. Robert J. Gallagher has been engaged by the Executive Committee to fulfill the administrative responsibilities of the Operating Agent.

The Agreement's administrative liaison at IEA Headquarters, Paris is Mr. Jayen Veerapen

SUMMARY OF RESEARCH ACTIVITIES

RESEARCH ACTIVITIES
FOR A PROGRAM OF APPLIED RESEARCH,
DEVELOPMENT, AND DEMONSTRATION
IN ENERGY CONSERVATION AND
EMISSIONS REDUCTION IN COMBUSTION

Introduction

The Implementing Agreement for A Program of Applied Research, Development, and Demonstration in Energy Conservation and Emissions Reduction in Combustion requires that the Executive Committee define and adopt detailed specifications for each research task undertaken within the program.

For most of its existence the Agreement consisted of a single Annex comprised largely of individual/single investigator tasks. Although this model worked well, the Executive Committee recognized that more attention should be paid to multi-nation/multi-investigator collaborative tasks. As the result of a series of strategic planning meetings six broad areas were identified for collaborative task development. In the spring of 2011 this culminated in an expansion of the number of Annexes within the Agreement such that each of these collaborative research areas were designated as a separate Annex. At the same time the original concept of single contributor tasks was retained for those investigators who preferred to contribute in that manner.

Moving forward, the Agreement will be comprised of multiple Annexes with Annex 1 being reserved for single contributor tasks, Annexes 2 through 7 being multi-nation collaborative tasks and Annex 8 being supporting activities

Briefly the focus of the individual Annexes is summarized below:

Annex 1 --- Individual Contributor Tasks

This Annex has been planned to improve fundamental and applied combustion technology which is developed to provide predictive design capabilities for internal combustion engines, furnaces, and gas turbines. The Annex is divided into the following Areas:

Area 1: Advanced Piston Engine Technology
The objective of the cooperative work in this Area is the development of combustion technology, both analytical and experimental, that will provide improved models for advanced internal-combustion piston engines, namely lean homogeneous-charge, stratified-charge, and diesel engines. The research will contribute primarily to technology common to these engine concepts and will provide data bases and descriptive and predictive system codes, in addition to practical demonstrations

Area 2: Advanced Furnace Technology
The objective of the cooperative work in this Area is the development of combustion technology, both analytical and experimental, that will provide models for furnaces and boilers. The research will provide a data base and descriptive and predictive system codes, as well as practical demonstrations.

Area 3: Fundamentals
The objective of the cooperative work in this Area is to conduct theoretical investigations of the fundamental physical phenomena relevant to the combustion process as is called for in Areas 1, 2 and 4, and to support the development of new diagnostic techniques for application in the future.

Area 4: Advanced Gas Turbine Technology
This Area covers work related to the development of combustor and gas turbine modeling and verification, to the study of emissions formation and control mechanisms, and to practical studies in fuel injection and fuel/air mixing.

Annex 2: Sprays in Combustion

Spray investigations aim at a deeper understanding of the complex interrelated aerodynamic and thermodynamic mechanisms involved in transient & steady spray combustion, which are responsible for the tradeoffs among energy conversion efficiency, nitrogen oxides and soot emissions in advanced engines and combustors. Tasks in the context of spray propagation involve a wide set of investigations on atomization, fuel-air mixing and combustion under high temperature and high pressure, as encountered in advanced diesel engines, gas turbines – and to some extent also boilers

Annex 3: Homogeneous Charge Compression Ignition

The combustion process in the HCCI engine is mainly driven by the chemical kinetics. Thus the chemical properties of the fuel are of outmost importance. Many small molecule fuels like methane and methanol have relatively simple and well controllable combustion process but it has been shown that many fuels experience a two-stage ignition process with a time period between the two stages without significant heat release.

The intent of this Annex is to look into the interaction between HCCI and fuels. It will include activities for both the gasoline and diesel type of fuels and HCCI with fully premixed charge and direct injection.

Annex 4: Advanced Hydrogen Fueled Internal Combustion Engines

This Annex focuses on research concerning the use of hydrogen as a fuel in internal combustion engines. Both engines fueled by pure hydrogen as well as by hydrogen blends are within the Annex scope. Experimental and computational work is included. In fact, it is of special interest to the Annex to coordinate the interaction between these two types of investigations.

Annex 5: Alternative Fuels

The present day engine combustion technology has been fully developed for crude oil based traditional liquid fuels: gasoline and diesel fuel.

The aim of the Annex is develop optimum combustion of future fuels and thereby significantly reduce engine out emissions together with noticeable increase in engine efficiency. The development of combustion techniques focuses especially on synthetic and renewable fuels. This Annex concentrates mainly on road transportation. There is a potential of engine out emission reduction by 70% to 90 % or even more**.** Dedicated fuels need new combustion technology to meet optimal emission reduction.

Annex 6: Nanoparticle Diagnostics

This Annex focuses on research concerning the measurement of nanoparticles produced by combustion. The development of diagnostics to characterize the physical or chemical characteristics of the nanoparticles, and demonstration of the application of these diagnostics, are within the scope of this Annex. The development may include experimental, numerical, or both approaches to the research. Demonstration may be in-flame studies of nanoparticle formation and oxidation, or post-flame measurements of nanoparticle emissions.

Annex 7: Hydrogen Enriched Lean Premixed Combustion for Ultra Low Emission Gas Turbine Combustors

In response to national policies gas turbine manufacturers have set the goal to adapt their large gas turbines for CO2-mitigated power generation, whereby up to 90% of the carbon contained in the fired fossil fuel is captured and stored as CO2. In order to mitigate CO2 emissions Zero Emission Power Plant concepts are being explored on a global scale. Gas turbine based configurations are playing a significant role in these scenarios. Following up on the previously conducted collaborative effort on “Hydrogen enriched Lean Premixed Combustion for Ultra-Low Emission Gas Turbine Combustors” it is proposed to widen the future collaborative task activities to gas turbine combustion issues linked to respective Zero Emission Power Plant concepts.

Annex 8: Supporting Activities

The objective of the work in this area is to provide administrative support services and information dissemination as called for by the work in Annexes 1 - 7.

Additional information on any of the work areas may be obtained by contacting:

Dr. Robert J. Gallagher
Secretary, Executive Committee
IEA Combustion Agreement
5380 Mallard Drive
Pleasanton, CA 94566
USA
email: bobgall@aol.com

Implementing Agreement for Energy Conservation and Emissions Reduction in Combustion

Contributed Research Activities

Annex 1 Individual Contributor Tasks (None this Year)

Annex 2 Sprays in Combustion (Collaborative Task)

Finland – Modeling of Jets and Sprays
Sweden – Cavitation Modeling
Finland – Analysis of Spray Structure
Switzerland -- Measurements and Modeling
Finland -- Turbulent Jet Imaging
Japan -- Spray Analysis
USA – Studies of Hollow Cone Sprays
Sweden – Numerical Simulation of Fuel Jets

Annex 3 Homogeneous Charge Compression Ignition (Collaborative Task)

Sweden – PPC Fuel Effects
Japan – Supercharged HCCI Engine
Japan – PREMIER Combustion
Italy – Effects of Diesel Gasoline Blends
Korea – Diesel PCCI Combustion
United Kingdom -- Diesesline

Annex 4 Advanced Hydrogen Fueled Internal Combustion Engines (Collaborative Task)

Korea – Effects of Hydrogen and DME Injection
Canada – Hydrogen Enrichment Effects on HCCI
Japan – High Pressure Hydrogen jets

Annex 5 Alternative Fuels (Collaborative Task)

Korea -- Biodiesel Combustion
Belgium – Numerical Simulation of HCCI Combustion
Belgium – Flame Kinetics
Belgium – Liquid Biofuels in Heating Systems
Switzerland – Global Ignition Combustion Models
Finland – Combustion Technology for Synthetic Fuels
Italy – Experimental Spray Combustion Investigations

Annex 6 Nanoparticle Diagnostics (Collaborative Task)

Sweden – Soot Aggregation Effects on LII
Italy – Optical Properties of Soot
Sweden – Studies of Soot Formation
Italy -- LII Measurements of Soot Particles
Canada -- Particulate Emissions from Vehicles

Annex 7 Hydrogen Enriched Lean Premixed Combustion for Ultra-Low Emission Gas Turbine Combustors (Collaborative Task)

Switzerland – Zero Emission Combustion Technologies
Sweden – Optical Diagnostics in a Jet Engine
Korea – Pusan Clean Coal Centre

Annex 8 Supporting Activities

Invited Presentations

Austria --- IEA Biomass Gasification Studies
Sweden -- National Energy Policy

Special Session on Combustion Diagnostics

Sweden – Laser Diagnostics in Combustion
Sweden – Spray Diagnostics
USA – Laser Diagnostics in IC Engines
Canada – Optical Diagnostics for Soot Measurements
Sweden – Coherent anti-Stokes Raman Spectroscopy
Sweden – Photofragmentation Techniques
Sweden – "Dark" Species Detection
Switzerland – Synchrotron Based Spectroscopy