IOP Institute of Physics
Combustion Physics Group

NEWSLETTER **June 2008**

Issue no. 55

Contents

1. Editor’s corner

We apologise for not getting this newsletter to you earlier. A lot has happened during the time from our previous newsletter and you will find some interesting material here, especially an article on energy and combustion from three schoolchildren, which shows the intense interest that our subject raises. The “biofuels” issue has also featured quite heavily in the news and some material has been assembled for you by the editors. Hopefully the reader can form his/her own informed opinion about this thorny issue.

We welcome Catherine Gardner from Queen Mary University as our new co-editor replacing Nondas Mastorakos. As always, any contributed articles would be much appreciated. If you are a “Young Researcher”, you will receive £50 for an article.

Epaminondas Mastorakos
Catherine Gardner

2. Meetings and conferences

For more information on past and future meetings, including some presentations on-line, please see:
http://www.iop.org/activity/groups/subject/comb/Events/page_7059.html

2.1 Past meetings

The **21st International Colloquium on the Dynamics of Explosions and Reactive Systems** (ICDERS 2007) took place in Futuroscope, Poitiers, on 23-27 July 2007.

The **European Combustion Meeting 2007** took place in Chania, Crete, on 11-13 April 2007. For details on the meeting, see: http://www.combustioninstitute.gr.

The **Spring 2007 Meeting** focussed on **"Fuel cells"** and took place on 16 April 2007 at Fitzwilliam College, University of Cambridge. A range of talks were given, spanning hydrogen production and safety, the operation of various types of fuel cells, and more general perspectives from the viewpoint of the operator.

The **Autumn 2007 "Early-Career Researchers" Meeting** took place on 4th September 2007 in Loughborough University, Engineering Department. Some more details have been compiled by Dr. Andy Clarke in Section 2.3. Andy has taken the important step of requesting abstracts from the presenters and these abstracts are now included in the Newsletter for a more widespread dissemination.

The joint Combustion Group – Combustion Institute **Spring 2008** meeting was on **"Transportation Biofuels"** and was organised by John Griffiths and Kevin Hughes in Leeds. For details, see
http://www.combustion.org.uk/Programme_19_March.pdf

Our **Spring 2008** meeting took place in Leeds on 7 May concentrated on **"Oxy-fuel Combustion"**. The organizer was Alexey Burluka. Reports on this meeting will be included in the next newsletter and the contributed presentations can be found at: http://www.iop.org/activity/groups/subject/comb/Events/page_7059.html

2.2 Future meetings

The **32nd International Symposium on Combustion** will take place in Montreal in 3-9 August 2008. For registration and details, see www.combustioninstitute.org

Our **Autumn Technical Meeting 2008** will include talks on **Alternative Fuels and Combustion Strategies for Internal Combustion Engines** and will take place on the **18th September** at Fitzwilliam College, University of Cambridge. The organiser is Dr. Andrew Clarke (a.clarke@lboro.ac.uk).

A more extensive list of national and international conferences may be found at: http://www.combustion.org.uk/calendar.html

We remind that our group can provide some financial support for presentations to conferences through a travel grant; see Section 5 of this Newsletter.

2.3 Detailed report on "Early Researchers" meeting, 4 September 2007

The Early Career Researchers meeting is held every two years and aims to encourage PhD students and young researchers to present their work and provide a forum for contributions on current research in topics relevant to combustion physics. The meeting also provides a great opportunity to meet other researchers and industrialists interested in combustion. The meeting is sponsored by the IOP, EPSRC and industry and provides industrialists and academics alike with a broad view of current combustion research and creates a chance to meet potential recruits in the field. The meeting includes oral and poster presentations from leading research groups and active young industrial researchers in the field of combustion physics. The meeting is open to members and non-members of the Institute of Physics and is always an interesting and constructive day of presentations and discussions about current research topics in Combustion Physics.

This year's oral presentations focused on the application of optical diagnostic techniques and their development, thermo-acoustic excitation and fouling issues in refinery processes. The presentations were made by young researchers from both academia and industry, and during the lunch break there was a fantastic array of posters to peruse, all with an enthusiastic young researcher by the side ready to answer questions.

A number of companies supported this event by sending representatives to discuss research and employment opportunities with the young researchers, including Eon and Siemens Industrial Turbo-machinery.

The abstract for each presentation is detailed below and the winners of the numerous prizes awarded are also included. The next young researchers meeting will be in September or October 2009, and we hope that it will be just as well supported. If you are interested in presenting your research please look out for the first announcement early next year, and if your company would like to support this event by sending a representative please contact the Andy Clarke.

2.3.1 Abstracts of presentations

Three-Dimensional Visualization and Characterization of Combustion Flames through Digital Imaging

G. Gilabert, G. Lu and Y. Yan (gg35@kent.ac.uk)

Department of Electronics, University of Kent

The demand for improving efficiency and reducing pollutant emissions of combustion processes has increased the importance of advanced flame monitoring. New technologies for monitoring and characterization of combustion flames have become essential for an in-depth understanding and subsequent optimization of power plant operations. Digital imaging techniques have been proven to be a non-intrusive means of measuring flame characteristic parameters including size, location, brightness, temperature distribution and oscillation frequency. The well established 2D camera systems for flame imaging have been evaluated extensively on laboratory and industrial scale combustion test facilities in recent years [1, 2]. However, as a flame is a three-dimensional (3D) object, to fully understand the properties of a flame, 3D visualization and characterization of the flame are desirable. The Instrumentation Research Group at the University of Kent has been undertaking research in this area in collaboration with leading power generation organizations. For instance, Bheemul et al [3] developed a multi-camera system which can reconstruct the 3D geometrical models of a flame from its 2D images. Brisley et al [4] also demonstrated a single camera system for 3D temperature measurement of a flame by combining the tomographic and two-colour pyrometric techniques.

This paper presents the latest development and evaluation of a multi-camera imaging system for the 3D reconstruction of flame luminosity and temperature distribution. The system consists of three identical RGB CCD cameras, a set of mirrors and lenses and dedicated application software. The system is capable of capturing six flame images simultaneously from six different viewing angles. An

innovative computing algorithm, which combines the logical filtered back-projection algorithm (LFBP) and the algebraic reconstruction technique (ART), is developed for the 3D tomographic reconstruction of the flame luminosity from its six 2D images. The 3D temperature distribution of the flame is computed using the 3D luminous reconstructions based on the two-colour theory. Experimental results on a laboratory-scale gas-fired combustion test rig and an industrial-scale coal-fired combustion test rig are presented and discussed.

[1] G. Lu, Y. Yan and M. J. F. Colechin, 'A digital imaging based multi-functional flame monitoring system', IEEE Trans. Instrum. Meas., Vol.53, No.4, pp.1152-1158, 2004.
[2] Y. Yan, G. Lu and M. J. F Colechin, "Advanced monitoring and characterisation of pulverised coal flames," Fuel, Vol. 81, pp. 647-656, 2002.
[3] H. C. Bheemul, G. Lu and Y. Yan, "Three-dimensional visualization and quantitative characterization of gaseous flames", Meas. Sci. Technol, Vol. 13, pp. 1643-50, 2002.
[4] P. B. Brisley, G. Lu, Y. Yan and S. Cornwell, "Three dimensional temperature measurement of combustion flames using a single monochromatic CCD camera", IEEE Trans. Instrum. Meas., Vol 54, No. 4 pp. 1417 – 1421, 2005.

CARS Temperature Measurements in an Acoustically-Forced Lean Premixed Ethylene-Air Flame

R. S. M. Chrystie, I. S. Burns, G. Hartung and C. F. Kaminski
Cambridge University

The ability to measure temperature accurately in a lean premixed flame is of prime importance to combustion modellers, and hence designers of modern aero-engines, in predicting and controlling spontaneous oscillatory flame behaviour prevalent in such flames. Experiments have been performed in a bluff-body stabilised flame, in which acoustic forcing causes the fuel mixture flow rate to sinusoidally vary in time, under specific conditions that have been previously investigated by this research group. This allows for cross-correlation with past results from planar imaging of the same flame configuration. Multiplex nitrogen vibrational Coherent anti-Stokes Raman Spectroscopy (CARS) is used to accurately pin-point temperature within the acoustically-forced flame. This allows accurate temperature measurements to be made at all locations in the flame. The aim of this work is to complement the previous studies by inferring temperatures at various locations in the central cross-section of the flame under different parameters of forcing amplitude and frequency, bulk flow rate, and equivalence ratio. High-powered pulsed laser beams are overlapped at specified angles to generate a CARS signal. The recorded spectrum is fitted with a theoretically generated spectrum, in order to deduce the temperature at the point of beam overlap within the flame. Phase averaged temperature mapping of the flame can be performed by synchronising the phase of the acoustic-forcing to the laser pulse and the camera trigger.

A Near-IR, Broadband Supercontinuum Based Sensor for High-speed Combustion Analysis

R. S Watt, J. Hult
Laser Analytics Group, Dept. of Chemical Engineering, University of Cambridge

The ability to accurately study gas temperatures and concentrations in real-time and non-invasively allows studies of complex reactive processes in combustion process taking place inside engines or gas turbines. Diode lasers have become well established light sources for such non-invasive measurements based on absorption spectroscopy. They are cheap, robust, small and easy to operate, however, they suffer from several inherent limitations; their tuning range is short and only certain wavelength bands are available. Furthermore, they are not capable of ultra-fast wavelength tuning over wide ranges. In this study a supercontinuum (SC) light source is employed. Broadband supercontinuum radiation spanning more than 1000 nm in the near-IR (700 – 1750 nm) has been generated by pumping a standard single mode fibre with picosecond pulses at 1064 nm. The broadband SC pulses are then converted into rapid wavelength sweeps by dispersing the broadband pulses using high dispersion fibre. The dispersed SC beam is then passed through a gas sample and the transmitted intensity detected by a high bandwidth photodiode. The output of the photodiode is finally digitized using a real-time oscilloscope, making it possible to observe and store individual absorption spectra. A spectral resolution of up to around 0.0375 nm has been achieved in this way. Room temperature test species include; water, acetylene, ethylene and methane, where ro-vibrational absorption features lie between 1300 and 1700 nm.

Preliminary results, obtained by recording spectra of water, acetylene, ethylene and methane which all have ro-vibrational absorption features in the 1300-1700 nm range, show good agreement between experimentally recorded spectra and spectra simulated using the Hitran Database. The high repetition rates of the laser source (0.2-20 MHz) allows exceptionally rapid sensing, making it possible to average over thousands of spectra for applications with less demand on high temporal resolution. Concentration measurements at acquisition rates up to 115 kHz have been demonstrated. The entire system is fibre coupled, making it compact and easy to employ for a wide range of applications. Being able to observe multiple absorption peaks allows multi-species concentration and temperature measurements.

Modelling of Fouling in Crude Oil Pre-heat Trains to Reduce Furnace Duty and Emissions

Francesco Coletti and Sandro Macchietto
Department of Chemical Engineering, Imperial College London

In an oil refinery approximately 6% of the total crude throughput is consumed as fuel in the furnace of the crude distillation unit. This energy is necessary to keep the refinery running but can be reduced by minimizing the temperature drop over time at the furnace inlet. The furnace inlet temperature is greatly affected by the thermal efficiency of the pre-heat train upstream. This is a network of heat exchangers in which the crude oil is typically heated from ambient temperature to around 300 °C before entering the fired heater. It has been estimated that a drop of 1 °C in this temperature results in a 510,000 US$/year loss in the revenue for a typical refinery, with drops of 10-15 °C in a year not unusual.

Crude oil fouling of heat exchangers is the main cause of this heat duty decay in pre-heat trains. This decay can reach 5.1 MBTU/h/month and must be compensated for by burning more fuel in the furnace with consequent economic and environmental impact.

Solutions to mitigate fouling range from the use of chemical additives to the insertion of devices into the tubes that mechanically scrub the surface. Unfortunately, this is often not enough to prevent the necessity for periodic cleaning of the units, which adds further economic penalties to the operation. An improvement in the current heat exchanger design methodology, which is old but still used, would be greatly beneficial.

The fouling rate changes as a function of oil characteristics and local conditions, such as wall temperature and velocity, which are in turn affected by fouling. Current design methods neglect the local effects, the dynamics of fouling and any detailed mechanisms, in favour of lumped, steady-state, “averaged” heuristic models. This work is aimed at developing a mathematical model capable of describing local conditions in a single shell and tube heat exchanger undergoing fouling.
A distributed, dynamic model of a tubular heat exchanger is coupled with a fouling model. The local fouling resistance is calculated by application of the classic Ebert-Panchal model for crude oil fouling, a function of film temperature and wall shear stress. Crude oil physical properties are calculated with a specialised package for thermodynamic analysis.

Simulation results allow tracking quantitatively the temporal decrease in overall heat transfer coefficient due to the increased thermal resistance, caused by the foulant species depositing on the tube walls. The spatial dependence of the fouling layer along the tubes is also produced. For a 1-1 pass heat exchanger operating in counter-current flow, it is shown that the thickness of the fouling layer is lower at

the entrance of the tubes and higher at the exit. This is expected, as in such an operating configuration the hot end is at the exit of the tube side (entrance of the shell side) and according to the Ebert-Panchal model, the higher the film temperature, the higher the fouling rate.

So far the model does not consider the effects of fluid dynamics in the unit: a plug flow model is considered for both sides. Also, no interaction between the fouling layer and the fluid flow in the tubes is taken into account. However, the results are encouraging and highlight the potential of the chosen approach to increase the understanding of the complex interrelations between fouling rates, crude composition, heat exchangers geometry and debris depositions. Future improvements of the model will include interactions between the fluid dynamics within the unit and the fouling behaviour, leading to a design methodology for mitigating or eliminating fouling.

Passive Damper Investigation for Damping of Thermoacoustic Instability in a Tubular Combustion Chamber
Jochen Rupp, Rolls Royce

Modern gas turbine combustion systems are prone to thermoacoustic instabilities. This phenomenon takes place if oscillations of the heat release are in phase with acoustic pressure fluctuations inside the combustor (Rayleigh criterion). If this criterion is satisfied the amplitude of the pressure oscillation can rise rapidly and then cause structural damage to the combustion system.

A method of suppression of thermoacoustic instabilities in gas turbine combustors is to use a highly perforated combustor wall. The pressure wave causes an oscillating pressure drop across the perforated skin which in turn causes vortices to shed from the rims of the perforation. Therefore, the acoustic energy is transferred into kinetic energy due to vortex shedding which ultimately dissipates in the turbulent flow field. Small amounts of bias mass flows across the liner have been used to further enhance absorption of the acoustic energy.

This work describes tests with perforated liners on a tubular combustor test rig under unstable flame conditions. The test was carried out to prove that perforated liners with very low cooling flows are capable of suppressing thermoacoustic instability generated by a lean premixed pre-vaporized (LPP) gas turbine fuel injector under inlet pressure conditions up to 2.4 bar and inlet air temperatures up to 400°C. The acoustic absorption of the damper was determined under unstable flame conditions. Furthermore, the test results have been used to further validate the perforated liner model in a thermoacoustic low order network model which is used to simulate the thermoacoustic behaviour of combustion chamber designs.

Swirl Stabilised Flame Response to Forced Excitation at High Amplitudes

C. Gardner and S. M. R. Hosseini (catherine.gardner@qmul.ac.uk)
Department of Engineering, Queen Mary, University of London

Phase-locked OH* Chemiluminescence and Particle Image Velocimetry (PIV) measurements have been made to investigate the response of a lean premixed, swirl stabilised, methane/air flame to forced acoustic oscillations. Increasing amplitudes of excitation were applied, giving up to 25% r.m.s fluctuations in velocity about the mean. Experiments were conducted in two frequency ranges, between 80 and 120 Hz, and 180 and 220 Hz to examine the response of the flame and record non-linear behaviour at high amplitudes of excitation. Flow field structures captured with the PIV were used in conjunction with OH* chemiluminescence measurements to describe the variation of flame response as excitation amplitude was increased and non-linear behaviour observed. Analysis of the intensity distribution of the OH* within the flame revealed significant variations in heat release throughout the cycle, particularly under high amplitude forcing. The velocity maps revealed vortex roll-up and pulsation of the inner recirculation zone. The areas of maximum emission from the flame occurred within the high velocity annular jet or at the edges of the pulsating inner recirculation zone. Non-linearity of the flame response appeared to be linked to flame retention at relatively low equivalence ratios during the excitation cycle.

The Effect of Flow Rotation on Flame-Front Propagation

Edward Long
Loughborough University

This presentation details research carried out on the interaction between rotating flow structures and flame front propagation. The aim of this work has been to develop a suitable measurement technique, and algorithm, for the accurate measurement of local flame burning velocity within highly rotating flows. The experimental part of this work utilised a premixed charge of methane and air, through which toroidal vortex structures were formed ahead of a propagating flame.

The test rig, detailed in Figure 1, was used to produce the flame-front/vortex interactions. Within this rig, a premixed charge is ignited within a small cylindrical pre-chamber linked to the main chamber via a small orifice. As the flame propagates through the pre-chamber, unburned charge is pushed ahead of the flame front through the orifice, resulting in a toroidal vortex being shed into the main chamber. As the flame continues to propagate through the charge, it interacts with this vortex structure, distorting the flame and altering its burning velocity. The nature of the vortices produced in the main chamber is dependent on the diameter of the orifice and its internal profile. Also, adjusting the distance between the point

of ignition and the orifice plate controls the point at which the vortex/flame interaction takes place.

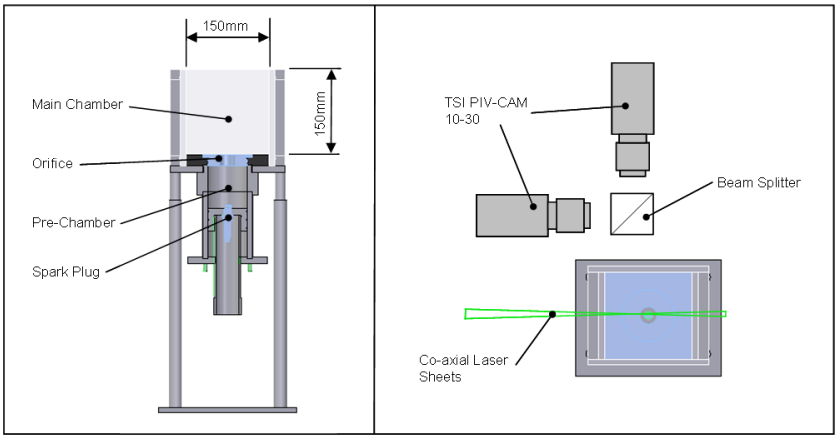

Figure 1. Schematic of the Combustion Chamber and the Twin Camera Set-up employed during the Asynchronous Particle Image Velocimetry Measurements.

The developed technique centres around the use of a re-sequenced version of Asynchronous Particle Image Velocimetry (APIV), a technique which enables the acquisition of the velocity flow field ahead of the flame front as well as displacement of the flame over a short duration of time (typically 100µs). This information enables the separation of the affects of flame advection (due to movement of the surrounding gases) and flame propagation. The velocity of the gas advecting the flame was calculated using adaptive grid Normalised Signal Strength (NSS) correlation. This allowed for small grid sizes to be employed locally to the flame front while maintaining low error.

In addition to describing the developed technique, the presentation will also contain examples of burning velocity data, highlighting how this information can also be linked to flow affects such as stretch rates.

The Investigation of Pressure Dynamics within a Lean Premixed Gas Turbine Combustion System

Ghenadie Bulat
Combustion Engineer, Siemens Industrial Turbomachinery Ltd

Combustion dynamics is currently one of the most challenging phenomena for the development of combustion chambers. As the drive to lower NOx levels is becoming more significant, gas turbines are forced to operate closer than ever to

lean stability limits. High combustion dynamics lead to a significant reduction in component life and in some cases restricts engines operation. Consequently, for some designs, there is a very small margin between sustainable operation and guaranteed emissions levels. To avoid gas turbine combustors experiencing excessive dynamics, a variety of tools have been developed to determine the characteristics of combustion dynamics, as well as tools for designing acoustic dampers for specific key frequencies. With the increasing availability of computational power, the prediction of combustion dynamics during the design phase of the product is becoming more feasible.

The presentation is intended to show an attempt to predict high frequency combustion dynamics using CFD and CSC (Combustion Stability Code), which is a linear acoustics tool. Results from the computational models will be benchmarked against high pressure (HP) rig test and full engine test data.

A full scale compressible transient CFD computation of a single combustor can of the Siemens SGT-200 gas turbine was performed. Analysis of the combusting flow dynamics for four sets of operating conditions, including sudden increases in the inlet fuel and air flows, were conducted. The computational domain had approximately 12 million unstructured cells, and extended from upstream of the burner air inlet to downstream of the 1st row nozzle guide vanes. The Scale Adaptive Simulation (SAS) turbulence model and the 2-step Eddy Dissipation (EDC) combustion model were used.

The Combustion Stability Code is a transfer matrix approach tool developed within Siemens that predicts frequencies that are likely to be experienced within the system. The code is based on blocks of known acoustic properties that are then connected together to simulate the system. The CSC code is linear with respect to pressure so it cannot predict the amplitude of the pressure excitation. The impact of using results from CFD, e.g. fuel time lag, temperatures and velocities, to set parameters in the CSC code will be discussed.

It was found that predictions from the CSC model were comparable with the HP and engine test results, though the model is sensitive to certain input parameters. This will be discussed in the talk. The CFD results show coherent structures (vortex shedding and precessing vortex core) in the combustor primary zone. An estimate of the frequencies of the structures is made. However, given that only a few cycles have been computed to date, the results must be treated with care. The work is currently in progress.

2.3.2 Winners

The prizes for the best presentations and posters are detailed below. Congratulations to all those who won, and thank you to all those who presented their research both orally and as a poster.

Prize	Name and address
Weinberg prize for best presentation. Sponsored by the IOP **£100**	**Edward Long** Loughborough University
Weinberg prize for best presentation: Runner-up **Certificate**	**Rosalynne Watt** University of Cambridge
Poster presentation: Best Contribution to public understanding Sponsored by the EPSRC. **£200**	**Mario Alons** Cardiff School of Engineering
British Flame Presentation: Best Industrially relevant research poster. **£200**	**Ghenadie Bulat** Siemens Industrial Turbomachinery Ltd
British Flame Poster: Best Industrially relevant research poster. **£150**	**Katherine Le Maquais** University of Nottingham

3. Contributed articles

The E.ON Schools Energy Conference 27th November 2007, Nottingham

By Kathryn Kroon (lhskrook@loughhs.leics.sch.uk)
Education Liaison, Combustion Physics Group
Head of Physics, Loughborough High School

Combining my role as a physics teacher, and my interest in energy and combustion, I was delighted to involve my school in the E.ON initiative 'Whose Responsibility is it? A working party of year 10 girls volunteered to initiate a survey amongst their year group and analyse the findings to establish their views on the important issues surrounding our future energy needs. They presented their findings as a report to E.ON and three students, Lucy Crookes, Serena Patel, Narges Mogishi were chosen to represent the school at the E.ON Schools Energy

Conference. A colleague of mine accompanied the girls to the conference, so I was anxious to hear their feedback.

The girls returned very excited about their day. They had taken part in a number of activities in which the major energy issues were discussed and they were particularly excited to have been interviewed by John Stapleton of GMTV about their report. The girls had put a lot of work into the project and the conference was a just reward for their efforts. An added bonus was that on their return enthusiasm for energy issues did not wane and they spent some time eloquently discussing them with their classmates in school. It is hard work getting extra-curricular initiatives off the ground in schools but this initiative managed to inspire a few motivated students in my school, whilst at the same time involving all the students in the year. We have also linked it with our school's 'Switch it Off!' initiative which is being given a high profile at the moment.

Also, as part of their project we invited a representative from E.ON to be interviewed about energy issues. Andy Boston from Power Technology spent a lunchtime with the girls answering their questions. This is their write-up of what they learnt.

E-ON Interview

On the 7th November 2007, a representative of the E-ON energy company visited our school. Mr Boston talked to Loughborough High School E-ON energy committee about what E-ON are doing to reduce carbon dioxide emissions. At E-ON they are examining different ways to generate electricity more efficiently.

Mr Boston informed us of the different renewable ways of generating electricity. These included onshore and offshore wind farms. On shore wind farms are cheaper but are becoming increasingly difficult to develop as people complain about them being an eyesore. Therefore their largest problem is getting planning permission. This is why E-ON have decided to build more off shore wind farms which can be situated up to 2 miles from the shore. Plans for building them in the Thames are being negotiated as they will produce 2000MW of electricity per year. However, these are very expensive and take a long time to develop. Also, only around 30% of days have enough wind to make them cost effective.

Another form of renewable energy being considered by this company is tidal power. E-ON are making plans to develop the first ever tidal power station that will be equipped with eight 1MW turbines. Good places to build these are in estuaries. The turbines are built in damns such as the River Severn barrage. However, these are very expensive to build, taking around ten years. Ecosystems and habitats are destroyed in this process, endangering wildlife as mudflats become exposed, jeopardizing certain birds.

Nuclear energy is also a possibility. This is being considered by E-ON and the government. A large problem is the public perception of the risks associated with a power station of this sort; people conjure up ideas about nuclear bombs. An even bigger problem is the nuclear waste produced. The waste is stored deep underground in stable rock formations in a solid form. The big advantage is that there are no carbon emissions while large amounts of energy are produced.

A renewable source of energy is solar power, though it is not very effective in the UK because of our lack of sunshine in the year. It costs around £5000 to £7000 to buy a water heating panel; though only £50 worth of energy is saved per annum. Therefore solar panels are not cost effective in this country, but in other countries where it is sunny for most of the year, solar panels are beneficial.

Another idea which E-ON has been looking into is the concept of capturing the CO2 as it is released. In fact, they are entering a competition, which as a result will tell us if this is possible. The hazard that the CO2 might leak is a big problem but they have discovered that oil companies have a use for it. The oil companies, such as Total and BP, find that CO2 helps to push the last drops of oil out of the wells, benefitting them as a company. It is possible to bury the CO2 because it is dense and will lie below ground in Aquaphers (a type of rock).

By 2015, half of all the UK's coal fired power stations will shut down, though the government do not want any fuel poverty. The people in the western world are the ones who need to develop solutions. If they succeed in doing this, other countries must follow in their path and solve the climate change problem.

Lucy Crookes, Serena Patel, Narges Mogishi, Loughborough High School, Year 10

Lucy (left), Serena (centre) and Narges (right) during the E-ON Energy Conference

4. Combustion in the news

Bio-fuels or Bio-hazard?

Biofuels have had a rollercoaster of publicity over the past few months, from being the long-sought solution to the global warming problem, to denounced as the culprit for increasing food prices and third-world hunger, an issue that the green party has been particularly vocal, calling for a halt in the use of large scale biofuels at their most recent party conference. The Green Party's concerns are not isolated and a number of high profile reports and reviews have been published in the recent past regarding the much publicized benefits of replacing our fossil fuel based energy production, yet tempering the excitement with issues of sustainability and the true environmental impact these fuels may have; especially if these fuels are produced in the quantities required to feed our increasingly energy hungry world.

Alternative fuels for automotive engines have recently been reviewed in the King Review, chaired by former Chief Executive of the Institute of Physics Prof. Julia King. The report dedicates an entire chapter to the consideration of alternative fuels in automotive engines, considering biofuels as a replacement to conventionally produced petrol and diesel and also as an additive to reduce the amount of petrol/diesel consumed. The advantage of this approach is that these fuels may be used in conventional IC engines, with some adaptation for blends of fuels with a high percentage of biofuel. This is attractive to consumers who may not wish to invest in a new vehicle or rely on what can be considered new/rarely used technologies such as hydrogen or electric vehicles, where the infrastructure for fuelling and engine maintenance is still emerging. The report comments that the life cycle analysis of fuels produced by plant based biofuels must be considered carefully and that the CO_2 emissions produced in farming the crops, processing and distribution of the fuel must also be taken into account when comparing energy source emissions. The balance between biofuel production and the CO_2 cost of land conversion to produce bio-fuels, or food crops displaced by biofuel crops, is also commented on. It is estimated that deforestation of land specifically for biofuel production may release up to nine times the amount of CO_2 than would be saved if the equivalent amount of land produced bio-fuel crops over 30 years. This does not seem very balanced, especially when the environmental impact of deforestation as a whole is considered (flooding, destruction of ecosystems and wildlife habitat etc).

The Royal Society has also recently reviewed the mechanisms and impact of biofuel production, focussing on fuels for transportation. The report was compiled after open call for evidence was made and several evidence gathering workshops and sessions took place. These involved representatives from environmental and development non-governmental organisations (NGOs), industries related to biofuels, including feedstock producers, fuel producers and the end use and

distribution industry took part. Their report gives an excellent overview of the mechanisms of biofuel production and refinement processes for many types of fuels, whilst considering the impact of production on both the environment and socially. The report concludes that biofuels have a limited, but potentially useful, ability to replace fossil fuel, largely due to technical and economic constraints. Also, the report comments that the refinement processes need to become more flexible, so that individual refineries can process numerous types of raw material, which will in turn could help to provide a continuous supply of fuel from various sources. The Royal Society also comments that for vehicle manufacturers to make the investments needed to ensure vehicles may operate on high proportions of biofuels, a long-term market for transport fuels containing a high blend of biofuels must be established. This may mean sticking with the government targets of ensuring 10 % biofuel content in transport fuels by 2010.

It is clear that governments around the globe have a long way to go to convince the public that biofuels can contribute to alleviating the looming energy crisis. It seems that the focus on environmental issues overshadows any concerns about the viability of these fuels for use with existing infrastructure and the investigations conducted by combustion scientists into how these fuels actually behave is generally unreported.

Some major investment in bio-fuel production and large scale testing of biofuel combustion has already been undertaken. Examples of these initiatives from 2006 are detailed below, and it would be very interesting to hear from our readers in the field regarding the commonality of biofuel use in 2008.

Co-firing biomass with coal is an effective way to incorporate biomass into existing infrastructure, Dr Nigel Burdett, Head of Environment, Drax Power Limited explained their strategy at the Autumn Combustion Institute meeting in 2006. At Drax, the largest coal fired power station in the UK, they have been incorporating short rotation coppice willow with coal to reduce their carbon emissions and aim to incorporate up to 10% biomass/energy crop per year (1-1.5Mt) by the end of 2009. Drax have adopted co-firing because it is the lowest cost renewable technology and in 2006 Drax was already capable of firing 5,000 tonnes/wk of solid biomass, this translated to a saving of >450,000 tonnes of CO2. Whilst the co-firing seemed to have the desired effect on emissions Dr Burdett did comment that it would be essential to development the biomass market/supply chain and that Drax power had already made much progress with local farmers, land owners and supplier groups with a focus on energy crops.

Chris Lewis from Rolls Royce outlined a gas turbine manufacturers view of biofuels at the IOP Combustion Physics Groups Autumn meeting in 2006. Gas turbines are designed to operate with a wide range of fuels, from natural gas, to diesel and

kerosine and it is this flexibility that makes them ideal candidates to utilize biofuels. However the quality, and stability, of fuels is very important for safe and reliable operation so all new fuels require rigorous testing and approval. Chris concluded that Bio-Fuel presented major technical, quality assurance and logistical issues at the time and has some interesting illustrations at the end of his presentation showing the damage that may occur to turbine components due to poor combustion and contaminants from these alternative fuels.

Due to the complexity of the topic both scientifically and ethically there is no wonder the amateur journalist can get carried away and become dogmatic and misinformed – especially since so much money is at stake!

Many combustion scientists and engineers who really know the topic have participated in the Combustion Physics Group's activities and have shown a much more professional and measured view. The links below can help bring back some perspective to the biofuels issue. Perhaps an emerging idea is that biofuels must be discussed in a holistic, integrated manner, i.e. including production, processing, usage and long-term environmental impacts. The CO_2 cost must be measured at every stage. Second-generation biofuels, those based on non-food crops for example, must have a role to play and may determine the progress of this technology in the next few years.

Biofuel Links: For those of you who would like some further reading on the topic of biofuels a number of links have been compiled below.

The King Review of low-carbon cars
http://www.hm-treasury.gov.uk/media/9/5/pbr_csr07_king840.pdf

Sustainable biofuels: prospects and challenges
http://royalsociety.org/displaypagedoc.asp?id=28632

The IOP Combustion Physics Group Meeting: Combustion of Biofuels Presentations.
http://www.iop.org/activity/groups/subject/comb/Events/page_8792.html

"Experience with the Combustion of Biomass" Dr Burdett, Drax.
http://www.combustion.org.uk/Cambridge%20Dec06/Burdett_Drax.pdf

The Green Party http://www.greenparty.org.uk/news/3160

BP biofuel factsheet
http://www.bp.com/liveassets/bp_internet/globalbp/STAGING/global_assets/downloads/B/Bio_biofuels_fact_sheet_jun06.pdf

CONCAWE, EURCA, JRC , Well-to-Wheels analysis of future automotive fuels and powertrains in the European context WELL-TO-TANK Report Version 2b, May 2006
www.senternovem.nl/mmfiles/Tank_to_Wheels_Report_EU_tcm24-195173.pdf

5. Group activities

5.1 AGM

Our Annual General Meeting took place together with the Combustion Institute Autumn Meeting at Imperial College. The minutes are available on line at our web site.

5.2 Travel Grants: Sources of Funding for International Travel

Every year there are a number of conferences dedicated to combustion research and associated techniques. To further understanding, disseminate findings and forge new collaborations conferences cannot be beaten in terms of accessibility to good science and good scientists, but while it may be a simple click of the mouse to submit an abstract, actually getting to the venue can be a challenge, particularly if you do not have a bottomless pit of cash to dip into, or the backing of a wealthy multi-national company - funding must be sought.

The IOP can provide assistance to travel to international conferences, but funding is limited, so it is always good practice to approach other sources of funding. First port of call should always be your institution, PhD students are usually entitled to attend one international conference as part of their training and post doctoral positions often have a small amount set aside for travel, however these sums may not cover the entire cost of the conference and are quickly used up over a studentship or medium term post-doc position. There are a number of associations and societies that fund scientific researchers to attend conferences and make short stays at host institutions or companies. Funding may be sought for conference fees, accommodation and travel; some sources will fund the entire trip, whilst more modest organisations may make a contribution to the total cost.

A number of bursaries are dedicated to funding researchers in a particular field or of a particular type (women, students, early career researchers), so it is worth looking at the fine print to ensure eligibility before beginning any application process.

The application process will vary from source to source and it is worth checking into what is required as soon as possible after the decision to attend a conference is made. This ensures adequate time to arrange references and write a convincing paragraph justifying the career enhancing possibilities of attendance at your chosen conference.

Most funding bodies will expect a report on return to ensure that their money was wisely spent. Each source will provide some guidance relating to the report content, but in every case mentioning the sessions and even individual

presentations that you found most interesting, and a brief description of how your presentation was received should be included. It is also important to mention any new collaboration's too. These reports are often published in newsletters like this one or on web, so bear in mind that your report will be in the public domain and write it accordingly.

Catherine Gardner

Table: Sources of Funding

Source	Description	Status/Deadlines
IOP Research Student Conference Fund	Specifically for research students to attend international meetings. Up to £250 may be applied for during the course of the PhD. http://www.iop.org/activity/grants/Research_Student_Conference_Fund/page_26535.html	Closing dates; **1 March, 1 June, 1 September or 1 December**
IOP CR Barber Trust	The CR Barber Trust Fund is open to members of the Institute, at an early stage of development in their careers, who wish to attend an overseas conference. http://www.iop.org/activity/grants/C_R_Barber_Trust/page_3139.html	Applications must be received at least one month before the start date of the conference.
Combustion Institute British Section	Provide travel grants to attend the Combustion Symposium for all students and those with an accepted paper to present. This year the program has been expanded to include both oral and poster presentations.	E-mail sent to members detailing application process.
Royal Society	This scheme is open for scientists who are working at postdoctoral level or above in the UK. Research must be on a subject within the natural sciences (physical or biological). The conference grants scheme supports UK based scientists to either present their own paper/poster or chair a session at an overseas conference, where conference participation is the main or sole purpose of visit. http://royalsociety.org/funding.asp?id=2348	The next round will be open on **3 April 2008.** Closing dates The next closing date will be **9 June 2008** Results available after 12 weeks.

Royal Academy of Engineering: International Travel Grant	The scheme is open to postgraduate students, doctoral and postdoctoral researchers, academic staff involved in research, in UK higher education institutions and chartered engineers in UK industry. To be eligible for funding applicants must be UK citizens or permanent residents. http://www.raeng.org.uk/research/researcher/travelgrant/default.htm	Grants of up to 50% of approved costs may be awarded to applicants. Grants are awarded throughout the year. See application instructions.
UK Resource Centre for Women in Science, Engineering and Technology.	The UKRC offers travel bursaries to help women (students, post-docs, academics and those in industry) to attend a conference or an event that will benefit their career. Unfortunately due to limited funding and unprecedented demand the bursary schemes are **currently closed.** http://www.ukrc4setwomen.org/html/women-and-girls/bursaries/	Further information of the new funding schemes will be available in late spring 2008**. Check website.**

5.3 Prizes

A number of prizes are awarded by the Combustion Physics Group including awards for excellent contributions to combustion physics by published paper, and an outstanding thesis award. The Combustion Physics Group also recognises significant and prolonged contribution to the field of combustion physics, most recently awarded to Prof. Derek Bradley. Details of each prize, including eligibility and the nomination procedure follow;

Ricardo award for best UK paper (£250)
The Ricardo sponsored award for best paper, first awarded in 2008, recognises any peer-reviewed UK or Irish paper accepted for publication in an archived journal or at the Combustion Symposium. The winning paper will include a significant technological advance or significance of the contribution in advancing understanding at a fundamental level and can be in any field of combustion physics for example diagnostics, measurements or computation.

The prize is awarded annually, later in the year than the Combustion Institute Symposium and an open call for nominations will be made, advertised through the IOP website and collaborating organisations such as the Combustion Institute, British Flame and EPSRC. The closing date for nominations is 31st July and the winner will be announced at the Combustion Physics Group AGM, which is usually held in September or October.

Huw Edwards prize for Services to Combustion Physics (£250)
The Huw Edwards prize for services to combustion is named after the late Prof. D. Huw Edwards, a world renowned scientist specifically interested in the phenomenon of detonations. Reviewed annually, but not necessarily awarded every year, the prize is awarded for either an important contribution to the field of combustion physics over a prolonged period of time, e.g. leading a strong research group over many years or a substantial contribution to education and training or otherwise raising the profile of combustion, for example by exemplary teaching in academia, or, successfully working with the popular media. The recipient may work in any field of combustion physics, for any individual or team based in the UK or Ireland and nominations sought from academia and industry. An open call for nominations is made, and advertised through the IOP website and the invitations sent out early in the New Year, with reminders issued towards mid-Summer, and a closing date at the end of August. The winner will be announced at the Early Career Researchers' meeting or the CPG AGM usually held in September or October.

Lefebvre prize for best UK PhD Thesis in the Field of Combustion Physics (£250)

A prize for the best thesis accepted by a UK or Irish University is awarded biennially and will be awarded for the first time in 2009. Theses are judged according to the significance of the contribution to the field of combustion and any difficulties that may have been overcome. The PhD can be in any field of combustion physics such as diagnostics, measurements or computation. Nominations are sought from PhD supervisors, and should include an extended abstract and supporting letter from the thesis examiners. This can be a copy of the report submitted by the examiners to the University after the thesis viva voce examination. Invitation for nominations are made early in the year with the closing date at the end of June. The winner is announced at the Early Career Researchers' meeting (September/October) following Combustion Physics Group AGM.

5.4 Services to Combustion Prize

The Committee has announced the Services to Combustion Prize during our "Early-Career Researchers" Meeting in September 2007. The happy recipient is Prof. D. Bradley from the University of Leeds. A dinner was held in Prof. Bradley's honour at the Polish Club in South Kensington, many thanks to all those who attended this enjoyable evening of celebration.

5.5 Benevolent Fund

The IOP has a Benevolent Fund for assistance to members in case of hardship. You can find information on it by logging in to the members area of the IoP Web site. To log in to the members area, use your membership number and surname.

5.6 Contact details

Web Page:
http://www.iop.org/activity/groups/subject/comb/Committee/page_27319.jsp

Committee:

This newsletter is also available on the web and in larger print sizes

The contents of this newsletter do not necessarily represent the views or policies of the Institute of Physics, except where explicitly stated.

The Institute of Physics, 76 Portland Place, W1B 1NT, UK.

Tel: 020 7470 4800
Fax: 020 7470 4848