

Administration Details

Venue

The venue for the course will be Weetwood Hall Conference Centre and Hotel which offers first-class hotel facilities, a business centre and ample parking facilities. Weetwood Hall is the largest and most flexible conference centre and hotel in the North of England.

Weetwood Hall Hotel is ideally situated 15 minutes north of the centre of Leeds in wooded grounds at the junction of the Otley Road and the outer ring road. It is just 15 minutes from Leeds Bradford International Airport and a short distance from the A1, M1, M606, M621 and M62 motorways. Further details can be found at www.weetwood.co.uk

Accommodation

Bed and breakfast accommodation is available at the course venue, Weetwood Hall Conference Centre and Hotel. To take advantage of the special rates we have negotiated with the hotel for our course delegates, please book using the instructions below:

1. Log onto: <http://www.engineering.leeds.ac.uk/short-courses/power-process/index.shtml>
2. Select "Ultra Low NOx Gas Turbine Combustion"
3. Click on the "Accommodation Booking" link in the left hand column
4. Complete the following fields: Arrival Date, Departure Date, Rooms, Adults, Children
5. Click the "Check Availability" button (N.B. You will not need to click on "Click Here for Special Rates" or enter a promotional code as this is already completed for you).
6. Proceed with your booking as instructed by the booking system.

We have negotiated the following special rates per night:

Friday – Sunday evening, bed and breakfast £62

Monday – Thursday evening, bed and breakfast £78

Please note that any accommodation bookings must be made two weeks before the course commences at the latest to qualify for the above rates and to guarantee room availability. Any accommodation requests after this date will be subject to availability and rates.

Delegates are responsible for their own evening meals except on Wednesday 18 January 2012 when the course dinner is included.

A list of alternative hotels is available on request.

If you are unable to complete your accommodation using the online booking system please contact Weetwood Hall Hotel directly at the contact details given on their web page at www.weetwood.co.uk

Course Dinner

The course dinner will be held at a Leeds city centre restaurant and is included in the course fee. This will take place on Wednesday evening and transport from and to Weetwood Hall Hotel is provided. The dress code is smart casual. If you would like to attend please indicate when booking.

Course Fees

The following course fees include the cost of tuition, course notes, lunches and light refreshments for the day(s) of attendance:

£1550 Full five days

£400 Any one day

Special Requirements

Potential delegates who have any special requirements should contact the course co-ordinator as soon as possible.

How to Book

Booking for this course should be completed through our secure Online Store. To complete your booking please follow the instructions below:

1. Log on to our Online Store at: <https://store.leeds.ac.uk/>
2. Select Conferences and Events in the left-hand navigation bar.
3. Select CPD Faculty of Engineering
4. Select the course or event for which you wish to register and click on "Book".
5. If you are a new user, please follow the instructions to register. If you already have an account log in as instructed.
6. Complete the application process as directed by the booking system.

You will receive an automatic confirmation email within 24 hours of your booking.

For online booking queries and for all other enquiries

If you are experiencing problems with booking online or have any queries about the course please contact:

Sophie Chopping/Jo Robinson,
CPD, Conference & Events Co-ordinator
CPD, Conference & Events Unit
Engineering Research & Innovation Service
Faculty of Engineering,
c/o School of Civil Engineering, Room 209
University of Leeds,
LEEDS, LS2 9JT, UK.

T: + 44 (0) 113 343 2494

F: + 44 (0) 113 343 2511

E: cpd@engineering.leeds.ac.uk

W: www.engineering.leeds.ac.uk/short-courses/

Potential delegates who have any special requirements should contact the above as soon as possible.

Terms and conditions for online booking

Payment in full should accompany your online booking. The course fee is exempt from VAT.

Registrations are accepted on the understanding that the printed programme is given in good faith but may have to be re-scheduled or the speakers changed for reasons outside our control. The University of Leeds reserves the right to cancel or postpone the course, in which case fees will be refunded in full. In the event of cancellation, the University will not be held liable for delegates travel or accommodation expenses.

Delegates will receive a full refund for cancellations made within 7 days of online booking, except where the booking has been made for an event commencing within the next 7 days. Where a delegate wishes to cancel a registration after this 7 day period, written cancellations received up to 15 working days before the course commences will be subject to an administrative charge of 20% of the total remittance. After this date the full fee is chargeable and no refunds will be made, this also applies for non-attendance but copies of the course documents will be sent. Substitutions may be made at any time.

If you are unable to complete your registration using the online booking system please contact the CPD, Conference & Events Unit to discuss alternative arrangements.



The University of Leeds

Faculty of Engineering



UNIVERSITY OF LEEDS

Ultra Low NOx Gas Turbine Combustion

Monday 16 – Friday 20
January 2012

Course Director:
Professor Gordon Andrews

Energy and Resources
Research Institute,
School of Process,
Environmental and
Materials Engineering

Please pass this leaflet to a
colleague if this course is not
relevant to you.

Image courtesy of GE Energy



Information about the course

Ultra Low NOx Gas Turbine Combustion

Monday 16 – Friday 20 January 2012

Background and Course Content

This annual short course, now in its Sixteenth year, is updated for each delivery with the latest publications on low NOx gas turbines.

Gas turbines are the main source of new electricity generating plants, but they have to meet severe NOx and CO emissions legislation in many countries. This course will address the technology options for industrial gas turbines necessary to meet 25ppm NOx regulations on liquid fuels and for 10ppm on natural gas (with 10ppm CO). The design options for low NOx combustors for liquid fuels for aero engine applications will also be discussed. With the advent of regenerative industrial gas turbines, for high cycle efficiency, creating very high combustor inlet temperatures of the order of 1200K, the NOx problem will be more severe and this problem will be addressed plus potential solutions outlined.

For aero-gas turbines NOx reduction is becoming more important with a new requirement for NOx reduction at cruise. Also the inlet temperature to the combustor is about 1000K with pressures of 60 bar at take off and this creates severe problems for NOx control. As only liquid fuels are viable for aero gas turbines the problem of fuel atomisation and auto ignition in premix ducts will be discussed.

Automotive gas turbines are under development (particularly in Japan) due to their potential to generate lower NOx and particulate emissions than current diesel engines. Automotive gas turbines have been demonstrated to easily meet Californian ULEV emissions regulations for CO and UHC and the new proposed 2005 EEC regulations as well as meeting the NOx regulations. SI and diesel engineers should be aware of this combustion technology and this course will provide the necessary information. To achieve a high thermal efficiency these engines already have regenerative heat exchangers and inlet temperatures up to 1200K are involved, with 1300K under development. The problem of low NOx emissions at very high inlet temperatures is greatest in this application, and there is more experience

in this area of very high inlet temperature low NOx systems. However, NOx reduction techniques at high inlet temperature will also have applications to aero engines and other high inlet temperature applications. Another area of current concern for low NOx is the supersonic transport, where very high inlet temperatures also apply and a target emission index for NOx of 5g/kg has been set by NASA and adopted by others.

The principles of low NOx designs are the same for all the applications of gas turbines and this course draws on information from the various gas turbine fields of aero, industrial and automotive as the cross fertilisation of ideas between the various areas is an important part of low NOx technology development. Each application area has its own specific problems, which will be discussed on the course.

Intended Audience

- Combustion designers in gas turbine manufacturers
- Operators of modern, low NOx electrical generation systems, including combined cycles
- Automotive emissions engineers
- Environmental legislators and regulators

Course Accreditation

This course is in association with the the **Institution of Diesel and Gas Turbine Engineers**, which is devoted to the advancement of Diesel and Gas Engines, Gas Turbines and related products and technology. The course has also been approved by the **Institution of Gas Engineers & Managers** for Continuing Professional Development (CPD) purposes.

The **Energy Institute** has approved Leeds University – Faculty of Engineering as an Approved Training Provider.

Full course programme

Lectures will be presented by **Professor Gordon Andrews, Energy and Resources Research Institute, University of Leeds, unless stated otherwise.**

MONDAY 16 JANUARY 2012

Fundamentals of NOx Formation

- 08.00 Registration and coffee
08.30 Introduction
09.45 GT cycles for low carbon and carbon sequestration, implications for NOx
10.45 Coffee
11.00 Thermal NOx formation kinetics
12.45 Lunch
13.45 The pressure dependence of NOx – experimental evidence reviewed
15.00 Thermal NOx control techniques
15.30 Tea
15.45 Exhaust gas recirculation and flowmeter combustion for low NOx and for high exhaust CO₂ for CCG applications.
16.30 Prompt NOx, including N₂O kinetics
17.15 Fuel nitrogen NOx – the importance of low level fuel nitrogen in NOx emissions from liquid fuels such as gas oil
18.00 End of day one
18.15 Welcome reception in Weetwood Hall bar

TUESDAY 17 JANUARY 2012

CO Emissions, Film Cooling, Flammability, Flame Propagation, Weak Extinction and Flashback

- 08.15 Registration and coffee
08.30 CO and hydrocarbon formation and destruction
09.45 The influence of film cooling on CO, UHC and NOx emissions and the requirement of no primary zone film cooling for minimum NOx and CO emissions
10.30 Coffee
10.45 Fundamentals of laminar and turbulent pre-mixed combustion and flammability limits
11.45 Weak extinction and lean flammability limits in premixed / prevaporised combustion
12.45 Lunch

- 13.45 Flame stability requirements of gas turbine combustors and their incompatibility with single stage low NOx combustors. Fuel staging or air staging?**
14.00 Turbulent flame propagation in premixed fuel/air mixtures
Dr Roth Phylaktou, Energy and Resources Research Institute, University of Leeds
15.15 Tea
15.30 Premix/prevaporisation duct design and NOx emissions
17.00 Acoustic instabilities in lean premixed low NOx combustors. Outline of the theory of acoustic instabilities in a tube with a sudden uniform heat release
Professor Andy McIntosh, Research Professor, Energy and Resources Research Institute, University of Leeds
18.00 End of day two

WEDNESDAY 18 JANUARY 2012

Premixed Low NOx Combustors and the Importance of Fuel/Air Mixing

- 08.15 Registration and coffee
08.30 Air staging low NOx combustors
09.30 Lean low NOx acoustic instabilities and pressure oscillations
10.30 Coffee
10.45 Lean low NOx acoustic instabilities and pressure oscillations – practical experience PH & P2
12.15 Conventional gas turbines: emission trends, internal flame composition to show the extent of bad mixing
12.45 Lunch
13.45 The importance of flame stabiliser pressure loss on fuel/air mixing and NOx: experimental evidence
15.15 Tea
15.30 Air assist atomisation of liquid fuels
16.30 Non-swirling baffle type combustors
17.30 The Alstom EV burner and UTRC/P&W TE burner
18.00 End of day three
19.00 Course dinner

THURSDAY 19 JANUARY 2012

Practical Lean Ultra Low NOx Combustors I

- 08.15 Registration and coffee
08.30 Axial swirl lean combustion
09.30 Development of the hybrid burner for the Siemens Gas Turbines
Dr Holger Streb, Siemens AG Power Generation, Muelheim, Germany
10.30 Coffee
10.45 Radial swirl lean combustion
11.45 The development process applied to Siemens Industrial Turbomachinery's dry low emission combustion technology
Eoghan Buchanan, Siemens Industrial Turbomachinery
12.45 Lunch
13.45 Counter-rotation axial swirlers
14.45 Counter-rotating radial swirlers
15.45 Tea
16.00 Fuel staging low NOx combustors
17.30 End of day four

FRIDAY 20 JANUARY 2012

Practical Ultra Low NOx Combustors II

- 08.15 Registration and Coffee
08.30 Industrial Gas Turbines at Rolls Royce
John Moran, Rolls Royce Engineering
09.30 Aero-gas turbine low NOx recent developments
John Moran, Rolls Royce Engineering
10.30 Coffee
10.45 Evolution of gas turbine combustion technology
Marcus Scholz, GE Energy, Europe
11.45 IGCC gas turbines for hydrogen fuel
Marcus Scholz, GE Energy, Europe
12.15 Lunch
13.00 Low NOx Technology: Alstom's premix and reheat combustors
Felix Güthe, ALSTOM, Switzerland
14.00 Lean/lean fuel staging without air staging
15.00 Tea
15.15 Rich/lean low NOx combustors
16.00 Catalytic combustion for low NOx gas turbines
16.45 End of day five and course

The full programme can be viewed online at www.engineering.leeds.ac.uk/short-courses/

Other Power, Process and Automotive Courses

- Energy from Biomass Combustion
- Combustion in Boilers and Furnaces
- Diesel Particulates and NOx Emissions
- Engine Emissions Measurement
- Chemical Plant Commissioning

What Our Previous Delegates Say

'Excellent course filled with lots of industry information. I highly recommend this course to anyone interested in Low NOx Gas Combustion'
Siemens

'Very interesting course, strongly recommended to those involved on Gas Turbine Combustion'
RWE npower