Monday 3 March 2014

BOILER AND FURNACE COMBUSTION AERODYNAMICS

Course Director: Professor Gordon Andrews

08.30 Registration and coffee

09.00 Fundamentals: stoichiometry, excess air, CO and NOx and flame radiation
Professor Bernard Gibbs, Energy Research Institute, University of Leeds
Stoichiometry, excess air and composition of products. Effects of air preheat and dissociation. Elementary flame radiation.

10.30 Coffee

10.45 Enclosed flow furnace aerodynamics
Professor Gordon Andrews, Energy Research Institute, University of Leeds
Free slot and round jets, velocity and concentration equations. Entrainment into free jets. Influence of swirl.

11.30 Free jet theories and swirling jets - Their application to furnaces and the prediction of flame lengths and the number of burners for boiler applications
Professor Gordon Andrews, Energy Research Institute, University of Leeds
Applications to the prediction of flame lengths and recirculation zone size in furnaces.

12.30 Lunch

13.15 CO Emissions
Professor Gordon Andrews, Energy Research Institute, University of Leeds

14.15 Fundamentals of low NOx burners
Professor Gordon Andrews, Energy Research Institute, University of Leeds

15.15 Tea

16.30 Low excess air low NOx burners
Professor Gordon Andrews, Energy Research Institute, University of Leeds

17.30 End of day one

19.00 Course Dinner

Tuesday 4 March 2014

LOW NOx BURNER DESIGN

Course Director: Professor Gordon Andrews

08.45 Registration and coffee

09.00 Emissions regulations for combustion in boilers and furnaces
Dr Steve Griffiths, EON New Build & Technology

10.15 Coffee

10.30 Internal and external flue gas recirculation for NOx control and flameless combustion
Professor Gordon Andrews, Energy Research Institute, University of Leeds

12.00 Refinery burners, including ultra low NOx burners, and process heaters
Tom Gilmartin, BP International
Refinery and petrochemical process heater types, design principles, engineering modelling, fuels, demands on burners, emissions constraints, heavy fuel oil burners, gas burners, burner testing, low NOx, ultra low NOx and sub-10 ppm NOx burners.

13.00 Lunch

CFD USE IN BURNER DESIGN

14.00 Application of CFD to Power Station Burner and Furnace Design
Phil Stopford, ANSYS UK Ltd
Introduction to numerical simulation of turbulent combustion of gas, liquid and solid fuels. Application to low NOx burner design and optimisation of multi-burner furnace operation.

15.00 Tea

15.15 Practical application of CFD to solve combustion problems on fired heaters
Tom Gilmartin, BP International

16:00 Industrial Case Study – ‘CFD solving a combustion problem’
Miles Coppinger, Wavin UK
Wednesday 5 March 2014

**BOILER AND FURNACE FUELS**

Course Director: Professor Bernard Gibbs

08.45  Registration and coffee

09.00  **Liquid fuel combustion and fuel properties**

   Tom Gilmartin, BP International

09.45  **Fuel properties: Gaseous (natural gas, LPG, Biogas, gasified coal and liquid fuels)**

   Professor Bernard Gibbs, Energy Research Institute, University of Leeds

   Composition, calorific values and air requirements. Flammability limits and burning velocities.
   Significance of gas composition, temperature, pressure and oxidant composition on burning behaviour.
   Blending of fuel gases.

10.30  Coffee

10.45  **Natural gas process burners for low NOx**

   Danny Brennan, Consultant

11.30  **Coal as fuel in boilers and furnaces**

   Professor Bernard Gibbs, Energy Research Institute, University of Leeds

   Coal rank and coalification. Variation of coal properties with rank. Proximate and ultimate analysis.

12.15  Lunch

13.00  **Burner air-gas ratio control**

   Danny Brennan, Consultant

   Principals of air-gas ratio control and how their selection can affect the efficiency of gas fired process heating plant.

14.00  **Oxy/fuel burners**

   Roger Dudill, Consultant

15.00  Tea

15.15  **Bio and waste derived oils**

   Professor Paul Williams, Energy Research Institute, University of Leeds

   A description of the production processes and fuel properties of oils derived from biomass and waste.

16.15  **Co-firing with bio-fuels**

   Professor Bernard Gibbs, Energy Research Institute, University of Leeds

17.15  End of day three

Thursday 6 March 2014

**INDUSTRIAL BURNERS**

Course Director: Professor Bernard Gibbs

08.45  Registration and coffee

09.00  **Testing and development of low NOx burners**

   Paul Newman, Hamworthy Combustion Ltd

09.45  **Oxy/fuel and FGR for carbon capture**

   Professor Bernard Gibbs, Energy Research Institute, University of Leeds

10.45  Coffee

11.00  **Burners for mineral processing kilns**

   Professor Barrie Jenkins, Associate Professor of Chemical and Mechanical Engineering, University of Adelaide –
   General introduction to processes and equipment, kiln and burner aerodynamics, fuel systems, mono and multi channel burner design, multi-fuel firing, emissions control, safety systems.

12.30  Lunch

13.15  **NOx emissions control for coal-fired boilers – technology layering & advanced reburning**

   David Moyeda, GE International Inc.

   Principles of emissions control technology layering and advanced reburning with an emphasis on full-scale performance applications.

14.00  Tea
14.15 **Selective non-catalytic reduction / selective catalytic reduction**  
*Rob Taylor, Doosan Power Systems Limited*  
Principles and application of two post-combustion methods of NOx reduction, involving its destruction by chemical reaction with nitrogenous compounds.

15.15 **Mercury emissions control technologies for coal-fired boilers**  
*David Moyeda, GE International Inc.*  
Fundamentals of mercury emissions formation and control from coal-fired boilers

16.00 **Boiler Optimisation**  
*David Moyeda, GE International Inc.*

17.00 End of day four

**Friday 7 March 2014**

**COAL COMBUSTION FUNDAMENTALS AND FLUIDISED BEDS**

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<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
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<tr>
<td>08.45</td>
<td>Registration and coffee</td>
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<tr>
<td>09.00</td>
<td>Fireside corrosion, slagging and fouling</td>
<td><em>Professor Bernard Gibbs, Energy Research Institute, University of Leeds</em></td>
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<td>Definitions, indices, sulphur trioxide formation.</td>
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<td>10.00</td>
<td>Boiler efficiency determination and control</td>
<td><em>Professor Bernard Gibbs, Energy Research Institute, University of Leeds</em></td>
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<td>10.45</td>
<td>Coffee</td>
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<td>11.00</td>
<td>Pulverised coal and char burnout fundamentals</td>
<td><em>Dr Valerie Dupont, Energy Research Institute, University of Leeds</em></td>
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<td>Introduction to combustion of pulverized coal, mechanistic steps of the combustion, effect of furnace temperature.</td>
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<td>12.00</td>
<td>Introduction to theoretical model of char particle combustion</td>
<td><em>Dr Valerie Dupont, Energy Research Institute, University of Leeds</em></td>
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<td>Derivation from first principles of diffusion rates of oxygen into the particle and of CO and CO₂ away from the particle. Derivation of oxygen concentration profile around the particle.</td>
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<td>Lunch</td>
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<tr>
<td>13.45</td>
<td>Combustion rates and burning times at various temperature regimes</td>
<td><em>Dr Valerie Dupont, Energy Research Institute, University of Leeds</em></td>
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<td>Derivation from first principles of the rates of combustion and burning times of char particles in conditions of external burning, internal burning and combined external/internal burning.</td>
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<td>14.45</td>
<td>Burning time for a suspension of polysized coal particles in a practical furnace</td>
<td><em>Dr Valerie Dupont, Energy Research Institute, University of Leeds</em></td>
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<td>Calculation using iterative solution from first principles of burning time for a pulverized coal fuel with a known distribution of particle sizes, specified excess air and furnace temperature. Relevance to practical case.</td>
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<td>15.15</td>
<td>Tea</td>
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<td>15.30</td>
<td>Fluidised bed combustion</td>
<td><em>Professor Bernard Gibbs, Energy Research Institute, University of Leeds</em></td>
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<td>16.30</td>
<td>End of day five and course</td>
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