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DESIGN OF CIRCULATING FLUIDIZED BED BOILERS:

Design of Circulating Fluidized Bed (CFB) Boiler Components, Furnace Design, CFB Boiler Design with External Fluid Bed Heat Exchanger, CFB Boiler Design Without Cyclone, Design of Water Wall, Superheaters, Reheaters, Loop Seal and Expansion Joints, Design of Refractory and L-Valves, Material Selection for a CFB Boiler, Major Operating Problems and Solutions in a CFB Boiler, Design of Supercritical Once-Through CFB Boiler

09 - 11 MAY 2018, MANILA, PHILIPPINES

Expert Course Faculty Leader

Philip Kiameh

Has more than 32 years of practical engineering experience with Ontario Power Generation as an Engineering Supervisor and Training Manager, has conduct courses and seminars, to more than 4,000 working engineers and professionals who consistently ranked him as "Excellent" or "Very Good". Philip has also wrote 5 books for working engineers from which three have been published by McGraw-Hill, New York.

Topics Covered

- Advantages of CFB Boilers
- Hydrodynamics in CFB Boilers
- Combustion in CFB Boilers
- Control Systems of CFB Boilers
- Design of a Circulating Fluidized Bed Boiler
- CFB Design with External Fluid Bed Heat Exchanger
- Corrosion and Erosion Potential in a CFB Boiler
- Maintenance Solutions to Common Problems Found in CFB Boilers
- Ultra Supercritical Fluidized Bed (CFB) Boilers

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DESIGN OF CIRCULATING FLUIDIZED BED BOILERS

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Introduction

This seminar will provide a comprehensive understanding of the design of circulating fluidized bed (CFB) boilers. The design of all CFB boiler components and equipment including furnace, cyclones, economizers, superheaters, reheaters, loop seals, expansion joints, refractory, and L-valves will be covered in detail. All potential operating problems and major operating problems, corrective actions and maintenance required for CFB boilers will be covered thoroughly. This seminar will focus on designing CFB boilers that have the highest efficiency, and maximum longevity and capacity factor. All the common problems encountered in CFB Boilers will be discussed in detail. This includes thermally induced failures, anchor system induced failures, and water walls tube failures, NMEJ damages, clinker formation, refractory damages, APH tube chock-up, erosion and corrosion. The solutions to each of these problems will be presented. All repair and refurbishment methods, preventive and predictive maintenance required for CFB boilers will be covered in-depth.

Several studies have confirmed that CFB boilers are the best method for power generation. This is due to their fuel flexibility, and lowest electricity cost among all types of boilers. This technology is in great demand due to various other advantages such as lower emissions as compared to other types of boilers and has a carbon footprint well below the norms laid down by the World Bank emission requirements. This seminar is a MUST for anyone who is involved in the design, operation or maintenance of circulating fluidized bed boilers, because it covers how these boilers are designed and provides guidelines and rules that ensure the CFB boilers have great performance. This seminar will also provide up-dated information in respect to the design of supercritical once-through CFB boilers and ultra supercritical CFB boilers.

Seminar Outcomes

- **Circulating Fluidized Bed Boiler Design:** Gain a thorough understanding of the best design methods of circulating fluidized bed boilers.
- **Design of Circulating Fluidized Bed Boiler Components and Systems**: Learn all the techniques used to design CFB boiler equipment and systems including furnace, cyclones, economizers, superheaters, reheaters, loop seals, expansion joints, refractory, and L-valves.
- **Design of Circulating Fluidized Bed Boiler to Achieve Highest Efficiency, and Best Performance and Economics:** Gain a thorough understanding of all the methods used to design CFB boilers having the highest efficiency, longevity and capacity factor as well as best economics.
- **Circulating Fluidized Bed Boiler Equipment:** Learn about various equipment of circulating fluidized bed boilers including: furnaces, cyclones, economizers, superheaters, reheaters, ammonia injection systems, electrostatic precipitators, polishing dry scrubbers, fuel and sorbent feeding systems, bottom ash handling and extraction systems and materials
- **Circulating Fluidized Bed Boiler Environmental Emissions:** Learn about the monitoring and control of environmental emissions from circulating fluidized boilers
- **Circulating Fluidized Bed Boiler Instrumentation and Control Systems:** Learn about the latest instrumentation and control systems of circulating fluidized bed boilers
- **Circulating Fluidized Bed Boiler Reliability and Testing:** Increase your knowledge of predictive and preventive maintenance, reliability and testing of circulating fluidized bed boilers
- **Circulating Fluidized Bed Boiler Selection and Applications:** Gain a detailed understanding of the selection considerations and applications of circulating fluidized bed boilers
- **Circulating Fluidized Bed Boiler Maintenance:** Learn all the maintenance activities required for circulating fluidized bed boilers, to minimize their operating cost and maximize their efficiency, reliability, and longevity.
- **Circulating Fluidized Bed Boiler Refurbishment and Life Extension Methods:** Learn about life cycle cost, profitability, refurbishment, and life extension methods for all types of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boiler Commissioning:** Understand all the commissioning requirements of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boiler Codes and Standards:** Learn all the codes and standards applicable for circulating fluidized bed boilers.

Who Should Attend

- Engineers of all disciplines
- Managers
- Technicians
- Maintenance personnel
- Other technical individuals

Training Methodology

The instructor relies on a highly interactive training method to enhance the learning process. This method ensures that all the delegates gain a complete understanding of all the topics covered. The training environment is highly stimulating, challenging, and effective because the participants will learn by case studies which will allow them to apply the material taught to their own organization.

Your Expert Faculty

Philip Kiameh, M.A.Sc., B.Eng., D.Eng., P.Eng. (Canada) has been a teacher at University of Toronto and Dalhousie University, Canada for more than 25 years. In addition, Prof Kiameh has taught courses and seminars to more than four thousand working engineers and professionals around the world, specifically Europe and North America. Prof Kiameh has been consistently ranked as "Excellent" or "Very Good" by the delegates who attended his seminars and lectures.

Prof Kiameh wrote 5 books for working engineers from which three have been published by McGraw-Hill, New York. Below is a list of the books authored by Prof Kiameh:

1. Power Generation Handbook: Gas Turbines, Steam Power Plants, Co-generation, and Combined Cycles, second edition, (800 pages), McGraw-Hill, New York, October 2011.
2. Electrical Equipment Handbook (600 pages), McGraw-Hill, New York, March 2003.
3. Power Plant Equipment Operation and Maintenance Guide (800 pages), McGraw-Hill, New York, January 2012.
4. Industrial Instrumentation and Modern Control Systems (400 pages), Custom Publishing, University of Toronto, University of Toronto Custom Publishing (1999).
5. Industrial Equipment (600 pages), Custom Publishing, University of Toronto, University of Toronto, University of Toronto Custom Publishing (1999).

Prof. Kiameh has received the following awards:

1. The first "Excellence in Teaching" award offered by Poweredge Asia Training center, Singapore, December 2016
2. The first "Excellence in Teaching" award offered by the Professional Development Center at University of Toronto (May, 1996).
3. The "Excellence in Teaching Award" in April 2007 offered by TUV Akademie (TUV Akademie is one of the largest Professional Development centre in world, it is based in Germany and the United Arab Emirates, and provides engineering training to engineers and managers across Europe and the Middle East).
4. Awarded graduation “With Distinction” from Dalhousie University when completed Bachelor of Engineering degree (1983).
5. Entrance Scholarship to University of Ottawa (1984).
6. Natural Science and Engineering Research Counsel (NSERC) scholarship towards graduate studies – Master of Applied Science in Engineering (1984 – 1985).

Prof. Kiameh performed research on power generation equipment with Atomic Energy of Canada Limited at their Chalk River and Whiteshell Nuclear Research Laboratories. He also has more than 32 years of practical engineering experience with Ontario Power Generation (OPG - formerly, Ontario Hydro - the largest electric utility in North America). Prof. Kiameh retired from OPG in November 2016.

While working at Ontario Hydro, Prof. Kiameh acted as a Training Manager, Engineering Supervisor, System Responsible Engineer and Design Engineer. During the period of time that Prof Kiameh worked as a Field Engineer and Design Engineer, he was responsible for the operation, maintenance, diagnostics, and testing of gas turbines, steam turbines, generators, motors, transformers, inverters, valves, pumps, compressors, instrumentation and control systems. Further, his responsibilities included designing, engineering, diagnosing equipment problems and recommending solutions to repair deficiencies and improve system performance, supervising engineers, setting up preventive maintenance programs, writing Operating and Design Manuals, and commissioning new equipment.

Later, Prof Kiameh worked as the manager of a section dedicated to providing training for the staff at the power stations. The training provided by Prof Kiameh covered in detail the various equipment and systems used in power stations.

Professor Philip Kiameh was awarded his Bachelor of Engineering Degree "with distinction" from Dalhousie University, Halifax, Nova Scotia, Canada. He also received a Master of Applied Science in Engineering (M.A.Sc.) from the University of Ottawa, Canada. He is also a member of the Association of Professional Engineers in the province of Ontario, Canada.

DESIGN OF CIRCULATING FLUIDIZED BED BOILERS

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3 Day Course Outline

Day 1 – Advantages of CFB Boilers, Components of CFB Boilers, Typical Arrangements of CFB Boilers, Hydrodynamics in CFB Boilers, Combustion in CFB Boilers, Heat Transfer in CFB Boilers, Design of CFB Boilers, CFB Boiler Operation, Maintenance of CFB Boilers, CFB Boiler Safety, Control Systems of CFB Boilers, Common Problems and Solutions of CFB Boilers

- Advantages of circulating fluidized bed combustion
- Circulating fluidized bed combustion technology
- Development of circulating fluidized bed boilers
- Components of CFB boilers: wind box and grid nozzle, bottom ash drain, HP blower, cyclone separator, evaporative or superheat wing walls, fuel feeding system, refractory, solid recycle system (loop seal), wall tubes, kick out, limestone and sand system
- Typical arrangements of CFB boilers
- Hydrodynamic in CFB boilers: particle classification, regimes of fluidization, fast fluidization, hydrodynamic regimes in a CFB boiler, Hydrodynamic structure of fast beds,
- Combustion in CFB boilers: coal properties for CFB boiler, stage of combustion, factors affecting combustion efficiency, combustion in CFB, biomass combustion
- Heat transfer in CFB boilers: gas to particle heat transfer, heat transfer in CFB boiler
- Design of CFB boilers: design and required data, combustion calculations, heat and mass balance, furnace design, cyclone separator
- CFB boiler operation: Requirements before starting, grid pressure drop test, cold start procedure, fill boiler procedure, start fan, boiler interlock, purge, start-up burner, drum and DA low level cut off, boiler warm-up, normal operation, normal shutdown, hot shutdown, hot restart,
- Malfunction and emergency: bed pressure, bed temperature, circulation, tube leak, drum level
- Maintenance of CFB boilers: Requirements before maintenance work, overview boiler maintenance, windbox inspection, furnace inspection, kick-out inspection, superheat (wingwalls), superheat (omega tube), roof inspection, inlet separator, steam drum, separator, outlet separator, screen tube, superheat tube, economizer inspection, air heater
- Basic boiler safety: warnings, general safety precaution, equipment entry, operating precautions
- CFB boiler control systems: Basic control, furnace control, main pressure control, main steam pressure control, drum level control, feed tank control, solid fuel control, HP blower control, primary air control, secondary air control, oxygen control, fuel oil control
- Boiler commissioning procedure
- Common problems and solutions of CFB boilers: wear problems in the boiler furnace, wastage in the boiler, thermally induced failures, anchor system induced failures, water wall tube failures (near lignite and subentry area), water wall tube failures at penthouse, main causes of tube failures, remedial actions, NMEJ failures, fitting of dust seal trap, clinker formation, remedial action taken, refractory damage, areas of major refractory damages, refractory damage in cyclones, APH tube chock-up, refractory failures at start-up burner and lignite entry area, chock-up in HP section

Day 2 – Design of a Circulating Fluidized Bed Boiler, Heat and Mass Transfer in a CFB Boiler, Furnace Design, CFB Boiler Configuration, CFB Design with External Fluid Bed Heat Exchanger, CFB Design Without Cyclone, Design of Heating Surfaces, Example of a Thermal Design of a CFB Boiler, Design of CFB Components

- Design of a CFB boiler
- Stoichiometric Calculations in a CFB boiler
- Heat and Mass Transfer in a CFB boiler
- Heat Balance
- Calcination loss
- Sulfation credit
- Unburnt carbon loss in ash
- Dry flue gas loss
- Moisture loss
- Division of solid stream (bed ash vs. fly ash)
- Control of particle size distribution in bed
- Furnace design
- Furnace cross section
- Width and depth ratio
- Furnace openings
- CFB boiler configuration
- CFB boiler without external heat exchanger
- CFB design with external fluid bed heat exchanger (FBHE)
- Design with internal fluid bed heat exchanger
- CFB design without cyclone
- Cooled cyclone versus hot cyclone
- Design of heating surfaces
- Disposition of heating surfaces
- Effect of fuel type
- Biomass fired CFB boiler
- Waste fired CFB boiler
- Heat absorption in external heat exchanger (EHE)
- Heat absorption in the furnace and back pass of the boiler
- Energy and mass balance around CFB loop
- Example of thermal design of a CFB boiler
- Design of CFB components
- Types of non-mechanical valves

- Principle of operation of non-mechanical valves
- L-valve, V-valve
- Loop seal (seal pot or J-valve)
- Design of L-valve
- Maximum solid flow rate through L-valve
- Practical consideration
- Design of loop seal
- Pressure balance
- Size of loop seal
- Design of loop seal
- Pressure balance
- Size of loop seal
- Intrex with J-valve
- Grate or fluidizing air distributor
- Types of distributors
- Design methods
- Fluidizing air distributor for CFB
- Nozzle plate design
- Practical considerations
- Plenum air loss
- Sealing distributor
- Attrition
- Back-flow of solids

Day 3 – Material Selection for a CFB Boiler, Corrosion and Erosion Potential in a CFB Boiler, Design Considerations of Refractory Lining, Potential Operating Problems with CFB Boilers, Failure or Degradation of Boiler Components, Design and Construction of CFB Boilers, Reduced Performance of the Total CFB Boiler or Specific Components, Prevention of Erosion and Corrosion in CFB Boilers, Maintenance Solutions to Common Problems Found in CFB Boilers, Supercritical Once-through Internal Recirculation-Circulating Fluidized-Bed (IR-CFB) Boilers for Power Generation, Ultra Supercritical Fluidized Bed (CFB) Boilers

- Material Selection for a Circulating fluidized bed boiler
- Pressure part materials in a CFB boiler
- Corrosion potential in a CFB boiler
- Erosion potential in a CFB boiler
- Selection of tube materials
- Commonly used materials in a CFB boiler
- Carbon and alloy steels
- Subcritical CFB boilers
- Supercritical CFB boiler
- Refractory and insulations
- Properties of refractory material
- Design considerations of refractory lining
- Anchors
- Areas of refractory use in a CFB boiler
- Refractory application
- Expansion joints in a CFB boiler
- Material-related problems in a CFB boiler
- Lower combustor
- Water-cooled cyclones
- Potential operating problems with CFB boilers: blockage of feed lines, loss in efficiency, material degradation, solid leakage, fouling, and agglomeration
- Major Operating Problems in CFB Boilers
- Failure of CFB Boiler Components
- Degradation of CFB Boiler Components
- Reduced Performance of the Whole CFB Boiler or Specific Components
- Design and Construction of the Boiler
- Options for Reduction in Erosion in CFB Boilers
- Corrosion Inside CFB Boilers
- Erosion-Corrosion
- Fouling and Deposit Formation Inside CFB Boiler
- Prevention of High Temperature Corrosion in CFB Boiler
- Use of Additives to Prevent High-Temperature Corrosion in CFB Boiler
- Reduction of Flue Gas Temperature at the Furnace Outlet
- Use of Corrosion Resisting Alloys
- Avoidance of Simultaneous Occurrence of High Gas Temperature and High Wall Temperature
- Avoidance of Contact of High Wall Temperature and Corrosion Agents
- Refractory Failure
- Thermally Induced Failures
- Anchor Failures
- Erosion Failures

This training course has a limited attendance for up to 20 participants only.

Sessions commence at 9am on all days, with short intervals at 10.30am and 3.30pm respectively.
Refreshments will be provided in the short intervals.
Lunch will be provided at 12:30pm for 1 hour. Sessions will end at 5pm on all days.

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09 -11 MAY 2018, MANILA, PHILIPPINES

	PER PARTICIPANT	2 PARTICIPANTS OR MORE	IN-HOUSE TRAINING
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