ADVANCED CIRCULATING FLUIDIZED BED BOILERS
Operation, Maintenance, Performance Monitoring, Diagnostic Testing, Troubleshooting, Refurbishment, Life Extension, Common Problems and Solutions

26 – 28 AUGUST 2019, KUALA LUMPUR, MALAYSIA

Expert Course Faculty Leader

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

TOPICS COVERED

- Circulating Fluidized Bed Boiler Operation
- Circulating Fluidized Bed Boiler Maintenance
- Circulating Fluidized Bed Boiler Components and Systems
- Circulating Fluidized Bed Boiler Application, Performance and Economics
- Circulating Fluidized Bed Boiler Environmental Emissions
- Circulating Fluidized Bed Boiler Instrumentation and Control Systems
Introduction

This seminar will provide a comprehensive understanding of the operation and maintenance of circulating fluidized bed (CFB) boilers. All the components of CFB boilers including furnace, cyclones, economizers, superheaters, reheaters, ammonia injection systems, electrostatic precipitators, polishing dry scrubbers, fuel and sorbent feeding systems, bottom ash handling and extraction systems, transformers and generators will be covered in detail. All operational problems, corrective actions and maintenance required for CFB boilers will be covered thoroughly. All diagnostic testing, troubleshooting, and refurbishment, procedures will be explained in detail. The emission limits, reliability, monitoring, control systems, and commissioning procedures of CFB boilers will also be covered. This seminar will focus on maximizing the efficiency, longevity and capacity factor of CFB boilers by improving operational practices and maintenance procedures. All the common problems encountered in CFB Boilers will be discussed in detail. This includes thermally induced failures, anchor system induced failures, 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 operation or maintenance of circulating fluidized bed boilers, because it covers how this equipment operates, the latest maintenance techniques, and provides guidelines and rules that ensure successful operation of CFB boilers. This seminar will also provide up-dated information in respect to all the significant improvements that have been made to the operational practices and maintenance methods for CFB boilers during the last two decades.

Seminar Outcome

- **Circulating Fluidized Bed Boiler Operation**: Gain a thorough understanding of the best operation practices 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 Components and Systems**: Learn about all components and subsystems of the various types of circulating fluidized bed boilers.
- **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, transformers and generators
- **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.
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.
About Our Expert Course Trainer

The trainer has been a teacher at University of Toronto and Dalhousie University, Canada for more than 25 years. In addition, He has taught courses and seminars to more than four thousand working engineers and professionals around the world, specifically Europe and North America. He has been consistently ranked as "Excellent" or "Very Good" by the delegates who attended his seminars and lectures.

The trainer 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 him:
5. Industrial Equipment (600 pages), Custom Publishing, University of Toronto, University of Toronto, University of Toronto Custom Publishing (1999).

The trainer 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).

The trainer 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). He retired from OPG in November 2016.

While working at Ontario Hydro, he acted as a Training Manager, Engineering Supervisor, System Responsible Engineer and Design Engineer. During the period of time that the trainer 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, he worked as the manager of a section dedicated to providing training for the staff at the power stations. The training provided by him covered in detail the various equipment and systems used in power stations.

The trainer 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.

- 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
- 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

Day 2 – Components, Operational Performance, Efficiencies, Availability and Reliability, Failure Modes, Operational Problems and Solutions, Maintenance, Methods Used to Improve the Heat Rate, Supercritical Once-through Internal Recirculation-Circulating Fluidized-Bed (IR-CFB) Boilers for Power Generation, Ultra Supercritical Fluidized Bed (CFB) Boilers

- Circulating fluidized bed combustion boilers
- Circulating fluidized bed combustion boiler and polishing scrubber
- Circulating fluidized bed combustion boiler combustor
- Circulating fluidized bed combustion boiler solid separation system
- Superheaters
- Economizers
- Reheaters
- Convective backpass
- Internal and external heat exchangers
- Fuel and sorbent feeding systems
- Air feeding and distribution system
- Bottom ash handling and extraction system
- Combustors of circulating fluidized bed boilers
- Cyclones of circulating fluidized bed boilers
- Circulating fluidized bed boiler process flow diagrams
- Wing walls
- Bubble caps
- Loop seal
- Refractory interface
- Tubular air preheater
- Coal feeders
- Ash coolers
- Start-up/Load burners
- Over bed burners
- CFB interlocks
- CFB control logic
- Boiler tube failures (22 primary mechanisms)
- Short term overheating
- High temperature creep
- Long term overheating
- Tube damage
Day 3 – Start-up System of CFB Boiler, Start-up, Load Operation & Shutdown, Operation Controls, Potential Operating Problems with CFB Boilers, Failure or Degradation of Boiler Components, 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

- Circulating fluidized bed boiler start-up burner, flame monitors, automation and instrumentation, purge, start-up burner basic logic, control principles
- Fuel oil pressure control, interlocking, troubleshooting, safety, starting problems of the burner, remedy, maintenance instructions, electric ignitor, flame detecting equipment, maintenance during shutdown, safety instructions
- Cold start-up, differential pressure test, bed material filling, burner start-up procedure, burner management system (BMS), furnace purging, natural gas firing, boiler pressurizing, coal firing, steam line charging for first boiler
- Operation Controls, bed temperature control, solid inventory control, furnace inventory control, part-load operation
- Hot start-up, warm start-up, boiler shutdown, emergency shutdown, fuel analysis, bed material specification, limestone, recommended feedwater quality
- Potential operating problems with CFB boilers: blockage of feed lines, loss in efficiency, material degradation, solid leakage, fouling, and agglomeration

- Water side deposits
- Dissimilar metal welds
- Caustic corrosion
- Hydrogen damage
- Hydrogen embrittlement
- Fly ash erosion
- Recommendations
- Fly ash erosion: typical locations; probable root cause, and corrective action
- Inspection Methods
- Mapping of thickness and identifying areas requiring repairs or replacement
- Steam erosion
- Falling slag erosion
- Tuning the boiler air regime for optimized combustion to avoid fouling
- Long term overheating (creep)
- Maintaining and monitoring the metal temperature within limits
- Ensuring adequate flow through tubes
- Following the start-up curves for rate of firing
- Boiler tuning
- Material upgrades
- Strict quality control during tube replacements to avoid foreign material entry
- Short term overheating
- Preventing blockage
- Maintaining the drum level
- Reduce overfiring
- Relocating welds away from highly stressed points
- Hydrogen embrittlement
- Water side corrosion
- Caustic gouging
- Monitoring and maintaining the water chemistry
- Avoiding corrosion products ingress
- Controlling copper deposition
- Chemical cleaning of the boiler
- Hydrogen embrittlement survey
- Replacement of damaged tubes
- Checking the fuel characteristics for fouling
- Preservation of the boiler during short and long outages
- Determination of the correct failure mechanism
- Safety valves
- Methods used to improve the heat rate of circulating fluidized bed boilers
- Supercritical Once-Through Internal Recirculation-Circulating Fluidized Bed Boilers (IR-CFB) Boilers for Power Generation
- IR-CFB Technology
- Controlled furnace temperature
- Low auxiliary power
- Uniform gas flow
- High solid separator reliability
- Minimal refractory use
- Low maintenance
- Dynamic load change
- Wide turndown ratio
- Operating experience
- Reduced diameter zone (RDZ) design for erosion protection at the upper refractory edge
- New commercial projects
- Arrangement of circulating fluidized bed boilers
- New developments in circulating fluidized bed design
- 300 MW IR-CFB boiler
- Supercritical once-through circulating fluidized bed with in-bed heat exchanger (IBHX)
- Internal Bed Heat Exchanger
- Supercritical once-through circulating fluidized bed design study
- Water and steam circuitry
- Flue gas path
- Reheat temperature control
- In-bed heat exchanger development
- In-bed heat exchanger design
- Open-bottom bed drain system
- Conclusions
- Ultra supercritical circulating fluidized bed boilers
- Efficient combustion and fuel flexibility
- Low Inherent NOx emissions at 50 – 200 Mg/NM3
- Low SO2 emissions with 95 – 98% sulfur removal
- Product specifications
- 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
- Erosion in CFB Boilers
- Principle of Erosion in CFB Boilers
- Fuel: Composition, Shape, Size, Hardness, Ash Content
- Operating Conditions: Temperature, Gas or Particle Velocity, and Gas Composition
- Tube Properties: Composition and Morphology of Tube Metal
- Design and Construction of the Boiler
- Workmanship in CFB Boilers
- Areas of Erosion in CFB Boilers
- Wall Tubes
- Wingwalls
- Fluidizing Grids
- Options for Reduction in Erosion in CFB Boilers
- Corrosion Inside CFB Boilers
- Corrosion Mechanisms in CFB Boilers
- Fireside Corrosion Fatigue
- Fireside Ash Corrosion of Superheater
- Chemistry of Fire-Side Corrosion
- Sulfate Corrosion
- Sulfide Corrosion
- Chlorine Corrosion
- Vanadium Corrosion
- Corrosion Potential in Biomass Firing
- Erosion-Corrosion
- Fouling and Deposit Formation Inside CFB Boiler
- Prevention of High Temperature Corrosion in CFB Boiler
- Low Oxygen Combustion
- Uniform Distribution of Combustion Air
- Uniform Distribution of Fuel in the Combustion Chamber
- 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
- Lower Combustor
- Upper Combustor
- Anchor Failures
- Erosion Failures
- Maintenance Issues
- Design Audit
- Material Audit

- Preventive and Remedial Measures for Fireside Corrosion
- Preventive Maintenance for Refractory
- Operating Issues
- Safety Issues
- Wind-box Explosion
- Accumulation of Carbon Monoxide in the Cyclone
- Explosion
- Excess Fuel in the Bed During Start-up
- Hot Solid Leakage from Furnace
- Operations Issues
- Combustion Start-up
- Cold Start-up
- Warm Start-up
- Alternative Procedure for Economic Start-up
- Hot Start-up
- Reduced Boiler Performance
- High Furnace Temperature
- Excess Emission of NOx and SO2
- Bed Agglomeration
- Fouling
- Loop-seal Problems
- Transformers
- Transformers Components and Maintenance
- Electric Generators
- Generator Components, Auxiliaries, and Excitation
- Generator Testing, Inspection, and Maintenance
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