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

07 - 09 NOVEMBER 2018, KUALA LUMPUR, MALAYSIA

Topics Covered
- Advantages of CFB Boilers
- Components of CFB Boilers
- Heat Transfer in CFB Boilers
- Design of CFB Boilers
- Common Problems and Solutions of CFB Boilers
- Methods Used to Improve the Heat Rate
- Ultra Supercritical Fluidized Bed (CFB) Boilers
- Commissioning Stages of the Boiler and Auxiliaries

Expert Course Faculty Leader
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". He has also written 5 books for working engineers from which three have been published by McGraw-Hill, New York.

SGD 2853 for 2 Participants or More

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Introduction
This seminar will provide a comprehensive understanding of various types of circulating fluidized bed (CFB) boilers. All the components of CFB 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 will be covered in detail. The design, selection considerations, operation, maintenance, diagnostic testing, troubleshooting, refurbishment, pay-back period, and economics as well as, emission limits, reliability, monitoring and control systems of CFB boilers will also be covered thoroughly. This seminar will focus on maximizing the efficiency, common problems and solutions, reliability, and longevity of CFB boilers by providing an understanding of the characteristics, selection criteria, common problems, and repair techniques, preventive and predictive maintenance. 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, NMEI damages, clinker formation, refractory damages, APH tube check-up. Solutions will be presented to each problem.

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 selection, applications, 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 this equipment during the last two decades.

Learning Outcomes

- **Circulating Fluidized Bed Boiler Advantages**: Gain a thorough understanding of the advantages of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers 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.
- **Circulating Fluidized Bed Boilers 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 Boilers Environmental Emissions**: Learn about the monitoring and control of environmental emissions from circulating fluidized boilers.
- **Circulating Fluidized Bed Boilers Instrumentation and Control Systems**: Learn about the latest instrumentation and control systems of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers, Reliability and Testing**: Increase your knowledge of predictive and preventive maintenance, reliability and testing of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Selection and Applications**: Gain a detailed understanding of the selection considerations and applications of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Reliability, Refurbishment, and Life Extension Methods**: Learn about the reliability, life cycle cost, profitability, refurbishment, and life extension methods for all types of circulating fluidized bed boilers.
- **Circulating Fluidized Bed Boilers Commissioning**: Understand all the commissioning requirements of circulating fluidized bed boiler.
- **Circulating Fluidized Bed Boilers Codes and Standards**: Learn all the codes and standards applicable for 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.
Who Should Attend

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

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 center 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.
3 Day Course Outline

DAY 1

- 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

DAY 2
Components, Operational Performance, Efficiencies, Availability and Reliability, Operational Flexibility, Fuel flexibility, Environmental Performance, 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

- 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

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- Furnace dimensions
- Lower furnace designs
- Solid separation systems
- Cyclones
- Impact separators
- sidewall membrane panels
- Optimized arrangement of solid separators
- External heat exchangers
- Scale-up
- Advanced circulating fluidized bed steam cycle with once-through boiler technology
- Availability and reliability
- Fluidized bed ash coolers
- Co-combustion
- Conclusions
- Status of circulating fluidized bed technology
- Operational performance
- Applications
- Recent developments in circulating fluidized bed combustion technology
- Scaling-up
- Advanced steam cycle with once-through boiler technology
- Other developments
- Oxy-fuel circulating fluidized bed combustion technology
- Oxy-circulating fluidized bed boiler design challenges
- Developments in oxy-circulating fluidized bed combustion
- Performance and costs
- Oxy-pulverized coal versus oxy-circulating fluidized bed boilers
- 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
- Segmented U-beam particle separators
- Proven design features
- High solid collection efficiency
- 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
- 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


- 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
• Testing and commissioning of CFB boiler and auxiliaries, commissioning stages of the boiler and auxiliaries, pre-commissioning checks, trial run of equipment, pre-commissioning tests, alkali boil out, thermal flow tests, chemical cleaning of the boiler, steam boiling, safety valve setting
• Commissioning of the boiler, reliability run of the boiler, typical boiler commissioning schedule
• Hydraulic test and wet preservation, purpose of the boiler hydrostatic pressure test, regulatory requirements for the boiler hydrostatic pressure test, state of the plant
• Air testing of pressure parts, boiler hydrostatic pressure test procedure, stage 1, hydrostatic pressure test of pressure parts, completion criterion for the boiler hydrostatic pressure test, Dry or wet preservation of the boiler
• Air and gas tightness test, test procedure, zones tested by the air and gas tightness test, furnace zone, second pass of boiler zone, electrostatic precipitator zone, forced draft fan ducts zone, hot air duct, cold air duct, primary air fan ducts zone, cold air ducts, hot air ducts, protocol on smoke generator test
• Trial run of equipment, fans, tests, constructional tests, commissioning checklist of induced draft fan, pre-commissioning tests, commissioning tests, fuel and limestone feed system, superheating system
• Electrostatic precipitators (ESP): components and operation, main components of ESP, basic diagram of ESP, rapping system of ESP, control cabinet, transformer, rectifier, hopper
• Main processes of an ESP, operation of an ESP, dust collection efficiency and electrical resistivity of dust, rectifier transformer, spark reaction, tripping, discharge electrodes
• ESP collecting electrodes, gas distribution system, rapping system, collecting rapping system, emitting rapping system, rapping system for distribution screen
• Rapper (electrostatic precipitation), rapppers and precipitators, types of rapppers, mechanical rapppers, pneumatic rapppers, tumbling hammers, design considerations
• ESP rectifier transformer, principle of operation, back corona, field short, voltage-current characteristics, parameters affecting the performance of ESP: gas temperature, moisture content, dust particle size, dust resistivity, rapping frequency, components of rectifier transformers
• SCR controller, transformer unit, current limiting reactor, rectifier diode assembly, high frequency choke
• Resistance board assembly – feedback signal for control and monitoring, mA feedback, kV feedback signal
• Insulating oil, characteristics of silicon oil, principle of operation, uni-pulse/semi-pulse mode, charge ratio, spark control rate, field current setting, specification – stage II transformers, transformer connections, open circuit test – BHEL transformer, short circuit test – BHEL transformer, acceptance test, fault detection
• Measures to be taken for avoiding frequent transformer failures
• Commissioning and testing of ESP, commissioning procedure of the electrical equipment inside the ESP, commissioning of the control system
• ESP no-load field charging test, transformer tests, open circuit test on transformer, short circuit test on transformer, insulation resistance of cables
• Commissioning procedure of the mechanical equipment inside the ESP, pre-commissioning checks – mechanical, gas distribution wall – bottom gaps and provision of inspection doors
• Before first light up of the boiler, gas distribution test, air load test of ESP

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.
### CIRCULATING FLUIDIZED BED BOILERS

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- By Cheque/Bank Draft: Make Payable to PowerEdge Pte Ltd.
- By Telegraphic Transfer: Please quote AE1 with the remittance advice

#### CANCELLATIONS & SUBSTITUTIONS

- You may substitute delegates at any time. POWEREDGE PTE LTD does not provide refunds for cancellations. For cancellations received in writing more than seven (7) days prior to the training course you will receive a 100% credit to be used at another POWEREDGE PTE LTD training course for up to one year from the date of issuance. For cancellations received seven (7) days or less prior to an event (including day 7), no credits will be issued. In the event that POWEREDGE PTE LTD cancels an event, delegate payments at the date of cancellation will be credited to a future POWEREDGE PTE LTD event. This credit will be available for up to one year from the date of issuance. In the event that POWEREDGE PTE LTD postpones an event, delegate payments at the postponement date will be credited towards the rescheduled date. If the delegate is unable to attend the rescheduled event, the delegate will receive a 100% credit.

#### RELATED TRAINING

- EPC Contract Management for Power & Utilities
- Electrical Generators & Excitation Systems
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- The 4 Pillars of Transformer Condition Monitoring

#### 4 ways to Register

- Online Web Registration
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